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THE EFFECT OF METHODS OF STORING AND TREATING POTATO SEED TUBERS ON THE SUBSEQUENT DEVELOPMENT OF THE POTATO PLANT

A thesis submitted for the degree of Doctor of Philosophy of the University of Edinburgh.

by

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INTRODUCTION

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Scotland is one of the leading countries in the world for intensive potato cultivation. The potato is now one of the chief Scottish cash crops. The expansion in production since the beginning of the century has occurred not only in Scotland, but also in England and Wales, the use of Scottish seed having had a marked influence on this expansion. The expansion is in part explained by increased acreage, and in part by an increase in yield.

Seed production is a much more specialised branch of the potato industry than ware production. Seed potatoes are much more expensive to produce, and prepare for the market, and success depends primarily on maintaining a high standard of quality. Seed potatoes may be produced either as crops managed specially for maximum seed production, or as a by-product of crops grown primarily for ware potatoes. Each of the above purposes for which potatoes are grown has an influence on the varieties grown. The cultivation of crops for seed production differs from that for ware, in respect of seed size, planting distances, and certain after-planting practices.

There are three ways of obtaining a high proportion of seed sized tubers, viz:- the planting of large setts, close spacing, and haulm destruction, the degree to which each or all of these practices is carried out, depends on how much importance is attached to the ware part of the crop, for each of these practices is adverse to ware production.

In Scotland, seed potatoes are produced for three purposes, firstly, to maintain the home acreage, secondly, for export to England and Wales, and thirdly, for export abroad. Mention is made of the Scottish seed trade to foreign countries, since it is an integral part of the Scottish seed trade, and also because in some respects it resembles the Northern Ireland export of seed to England. Scottish seed has to compete with Northern Ireland and English seed in the foreign market. At present the demand for high quality Scotch seed is increasing.

Variety, spacing and seed size are not the main criteria on which the present investigation is based. The object was to investigate the effects of different storage conditions and treatments on the number of tubers subsequently produced, with the object of seeing whether the seed tuber could be profitably manipulated during storage with the seed crop in mind. This may be an alternative to planting large tubers or close-planting in order to induce a maximum proportion of seed sized tubers. It was also intended to investigate the effects of sprout removal in riddling before planting and also to investigate the influence of a short period of heat treatment during low temperature storage, and the effect of sprouting seed tubers in the dark as a means of increasing the number of sprouts per seed tuber. In the present work two methods of storage were adopted to check the growth of sprouts for a reasonable period. They were (1) low temperature storage (40°F.) and (2) the application of a most commonly used sprout suppressing chemical, TCNB (2, 3, 4, 5 - tetrachloronitrobenzene: trade name FUSAREX).

We have studied particularily the sprouting of seed tubers at different dates, to see more precisely the factors affecting number of sprouts, and the means of getting more tubers per hill. Before describing ways and means of suppressing apical dominance in potato seed tubers, it is worthwhile mentioning here, in brief, what apical dominance means. Normal tubers, as a rule, will sprout from the eyes on the terminal or seed end of the tuber. These sprouts if not destroyed or too much impeded in growth, will inhibit the growth of sprouts from the other eyes. This inhibiting influence by the terminal sprouts on the growth of sprouts from the other eyes on a tuber is called "Apical Dominance". The causes of the terminal bud dominance over the growth of other buds on a stem is one of the most profound problems of plant growth, and has occasioned a great deal of research, but it has not yet definitely been solved. Several theories have been advanced to explain this property of plant growth.

It is known however, that potato tubers when trayed up early, i.e. immediately after lifting at a temperature above 50°F. produce one or two apical sprouts per set, irrespective of their size. When potato tubers are trayed up at a later period, the number of sprouts per set is increased i.e. from 2, 3 or more. The apical dominance is thus reduced gradually. When potato tubers are trayed up at a still later date, apical dominance disappears and the tubers are then in the multiple sprouting phase (e.g. Toosey (120,121). While mentioning the number of sprouts per set produced it is essential to mention here, the relation between the seed tubers and the number of sprouts produced under various conditions. Although varietal differences have been noted, there is a direct relationship between the size of the seed tubers and the number of sprouts and stems produced.

The foregoing consideration suggested a study of diverse factors by laying out multi-factor experiments, not only to evaluate their main effects but also their interactions. In the first year, attention was confined to the study of various storage treatments planted at two spacings (9" and 18") in two varieties, Arran Pilot and Majestic, the former an early variety, the latter an early main-crop variety. In the succeeding year one more factor i.e. seed-size was included in the trials.

REVIEW OF LITERATURE

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A. FACTORS INFLUENCING THE DEVELOPMENT OF SPROUTS

Burton (34) reviewed the literature on this subject and reported that the occurrence or non-occurrence of active sprout growth depended upon the biochemical state of the tuber, a state that is in continual change, partly in response to the environment. What chemical systems are involved in sprout growth is still a matter for speculation, but, in seeking to discover a cause for dormancy and sprouting, much information has been acquired about the variable factors which influence them. For this reason I will describe briefly most of the factors known to influence sprout growth, before passing on to the attempt which have been made to explain it.

1. Variety of Potato

Varieties differ markedly in their rate of sprout growth, although the extent to which their dormant periods differ is more difficult to assess. The differences in growth rate exhibited by two commercial varieties will be illustrated in our study. Arran Pilot sprouts very soon after harvest (sometimes before), and exhibits a very rapid rate of growth. The other one, Majestic, has a slow rate of sprout growth, and sprouting does not normally start until several weeks after harvest (66, 116, 146, 160, 195, 196).

2. Maturity of Tubers.

It is clear from the experimental evidence cited in discussing the definition of the dormant periods, that the more mature the tubers are when harvested, the less will be the period of dormancy from the date of harvest (34).

3. Size of Tubers.

Emilsson (66) has shown that large tubers sprout earlier than very small tubers from the same crop.

4. Pre-harvest Conditions

For the reasons discussed above, it is often not possible, in the absence of information regarding the time of tuber formation, to assess the effect of pre-harvest conditions upon the length of the dormant period. The length of day during the growth of the plants has been shown to have no effect upon the sprouting date of some varieties but a marked effect on that of other varieties (66); the effect of day length upon tuber formation is also a varietal characteristic (57). The time after harvest at which sprouting commences, under uniform conditions of storage, is shown to vary from year to year; to be influenced, not only by the source of the tubers, but also by the source of the seed tubers from which the crop was grown. Emilsson (66) found that infection with potato virus or with leaf-roll had no effect upon the sprouting date, but late blight (phytophthora infestans) advanced the date considerably (53, 66). Phytophthora infection occurs late in the growing season, after tuber formation, and thus the effect in this case is certainly a genuine shortening of the dormant period, due presumably, to biochemical changes in the infected tubers.

5. Temperature of Storage.

The temperature of storage is of great importance, and its effects have been studied by several workers (13, 106, 151, 157). Although different varieties of potato may vary somewhat in their response to different temperatures of storage, the broad picture, in the case of rate of growth at a constant temperature, is the same. Growth is very slow at temperatures of 5°C. and below, so slow that it may not be noticeable in varieties such as Arran Consul, in which sprout growth under favourable conditions is slow. On the other hand, those varieties, in which sprout growth is rapid under favourable conditions, may show slight growth after prolonged storage at temperatures as low as 2°C (106). Over the range 5°C to 15°C, an increase in storage temperature causes a marked increase in sprout growth. Above 15°C, this increase in growth is less marked (13), but some acceleration occurs until the optimum temperature (about 25°C) is reached.

The effect of storage temperature upon sprout growth is, however, at least two-fold, direct, by its influence upon the rate of cell division, and indirect, by its influence upon the composition of the subtrate (i.e. the tuber) on which the sprouts are growing. Both effects are complex. For example, the contents of sugar (12, 14, 124), ascorbic acid

(15, 102), and growth-promoting and growth-inhibiting substances (32), and the activities of various enzyme systems (31) in the tuber, are all subject to variation due to storage temperature. It is thus quite possible that storage at a temperature unfavourable to sprout growth may so alter the tuber, that, on subsequent transfer to a temperature favourable to growth, the rate of sprouting would be greater than it was in tubers stored continuously under other conditions. Whether or not the effect is favourable, previous storage history is practically certain to influence the rate of subsequent sprout growth at any given temperature.

The effects of storage temperature on the subsequent development of crops has been studied by a number of authors.

Ehrondorfer (61) reported that the number of shoots per plant, and parallel to this, the number of tubers per plant was considerably higher with seed pregerminated in the cold than with seed pregerminated in the warmth. Schulze (155) made a similar observation. Seed which germinated at 4°C to 7°C, had approximately 4-7 shoots per plant, whereas at pre-germination temperatures between 15°C and 20°C he counted only between 3 and 4 shoots.

Krijthe (107) observed the largest number of tubers on seed stored in the cold. The tubers remained small. These observations agree with the results of the experiments described above. Krijthe (107) explains this circumstance thus, that under warm storage, a precedence (dominance) of individual germs (sprouts) comes about. For, as Denny (47) explains in potato germination, only one bud develops from one eye, which prevents the other buds from germinating. Equally a growing sprout at the crown end prevents growth from other eyes. This growth regulation means that particularly in warm storage, as Krijthe (107) writes, only a few shoots, and thus also only a few relatively large tubers are formed per plant. With cooler storage, many more eyes shoot, for there is no particular precedence of individual sprouts during pregermination.

Hurst (100), from a series of tests designed to study the reaction of potato tubers subjected to low temperatures, found that sprouting tendences were influenced very largely by the duration of the exposure. At an air temperature of 24°F tubers exposed for 60 minutes produced sprouts of slightly greater vigour and size than did the unexposed check tubers. Sprouting capacity, however, was affected adversely by exposures to low temperatures. Definite relationships were indicated with respect to length of sprouts and duration of exposure. In general it appeared that the longer exposures were detrimental, especially at the lower temperatures, thus, exposure at 11°F for 25 minutes arrested sprout growth and caused necrosis and exterior spotting.

Jehle (101) studied the effect of various storage temperatures on sprout development, and found that Irish Cobbler seed potatoes produced numerous sprouts when stored at 40°F till 20th. February and 60°F till 20th. March. Apical dominance was suppressed and the sprout length ranged from ½" to ¾" long.

Mumford (125), in the U.S.A., stored northern-grown and home-grown potatoes at 31°F and 33°F. The northern-grown yielded 54.7 bushels after being stored at 31°F and 131.7 bushels after being held at 33°F. Home-grown potatoes gave only a 10 per cent stand when stored at these low temperatures.

Smith (158) stored two varieties, Irish Cobbler and Smooth Rural at 50°, 40°, 35° and 32°F for the entire period of storage and reported that plants appeared above ground in the order as noted above. The largest number of stems for each seed tuber was produced by tubers which had been stored at the high temperatures. The largest total number of tubers from each plant, as well as the largest number of U.S. No. 1 size tubers, were formed from tubers which had been stored at the higher temperatures. This is contrary to the results obtained by a series of authors (61, 107, 155). It appears, therefore, that some other factor or factors may play a role in getting a reversed result like this. Smith mentions that low yield at low temperature storage may be due to low humidity in this case, because certain lots of tubers in each of the cold storage rooms were kept at a high relative humidity (80 to 95 per cent) and other lots at a low relative humidity (40 to 50 per cent). The Irish Cobbler and Smooth Rural responded differently in yield of tubers to the same storage conditions. The largest yields of Irish Cobbler were usually obtained from storage at 40°F, whereas the highest yields of Smooth Rural resulted from storage at 50°F.

Stuart (164) has reported that potatoes stored at 31° to 33°F were less productive than those stored at 38° to 40°F. The exact method, he said, of storing the seed is somewhat immaterial if the seed is in the proper condition at planting time. In comparing storage at 40° and 35°F and at 35° and 32°F Hartman (87) obtained greater yields with the higher temperatures. He attributed the increase to the earlier plant emergence, which provided green plants in the field for a greater number of days.

Werner (190) studied the sprouting behaviour of seed potatoes in a large storage bin and reported that the time of sprouting was correlated very closely with the temperature in various portions of the bin. In the 50°F testing room, 50 per cent of the tubers from the upper control part of the bin were sprouting within 3 days, but about 10 or 11 days were required for the same amount of sprouting in those from the central part of the floor, and upper part of the front wall, and about 17 days for those along the rear wall. Those along the side walls, especially in the upper part of the bin, sprouted several days later than those on the same level in the middle longitudinal section of the bin.

Some of the earlier work to determine the effect of storage temperature on productivity of seed potatoes was conducted from 1919 to 1924 at Arlington and Norfolk, Virginia, by Stuart, Lombard and Peacock (166). With Irish Cobbler the differences (in favour of higher temperatures) in the yield from tubers stored at 32°, 36° and 40°F were very small and consistent, but with Green Mountain potatoes grown as a fall crop at Arlington, the lowest yields were produced by seed potatoes held at 32°F and highest by those at 40°F. With the 1921 crop a gain of 14.5 per cent in total yield and 26 per cent in yield of prime tubers, occurred when seed potatoes were stored at 70°F, 12 days before planting, following winter storage at 32°F and 40°F. Bushnell (35) reported 11 per cent more production in Ohio during 4 years from seed tubers stored at cellar air temperatures of 36° to 38°F than from those stored at 32° to 33°F.

Potatoes stored at 40° and 50°F by Peacock and Wright (139) sprouted earlier, produced a better stand, matured the crop earlier and produced greater yields than did those held at 32°F.

6. Humidity of Storage

Very little information regarding the proper degree of humidity to maintain in the storage house or room is avialable. The question as to whether the humidity of the air should be high or low is one to which the data at hand do not permit a satisfactory answer. Cooper (42) suggested a humidity of from 85 to 90 per cent as about correct for a potato storage room when the temperature renged from 33° to 35° F. This suggestion coincides with that of Stuart (167).

Smith (158) studying the influence of storage temperature and humidity found that low humidity in storage resulted in the lowest number of sprouts to each seed tuber but in the longest individual sprouts in the varieties Irish Cobbler and Smooth Rural. With Irish Cobbler yields from the later planting were the largest for treatments at 40°F - high humidity, and at 40°F - high humidity, desprouted. The lowest yields were obtained from treatments at 32°F - high humidity, at 50°F - high humidity desprouted, and at 50°F - low humidity. With Smooth Rural yields for the later planting were the largest for the treatment 40°F shifted to 50°F. The lowest yields were obtained from treatments 32°F then 50°F; 32°F then 40°F; 40°F then 32°F; and 50°F - high humidity. Smith also showed that low humidity appeared to accelerate apical dominance of the sprouts.

Vincent (180) stored potato seed tubers in different types of environments, such as a flour mill basement, a dwelling house basement, greenhouse, pit, and reported that poor aeration favoured greater relative humidity with a possible consequent lessened loss through sprouting and shrinkage.

The humidity of the storage atmosphere (34) may affect the rate of sprout growth, particularly when this is well advanced, and also the form of the sprouts, e.g. the degree of branching or of production of adventitious roots. Emilsson (66) found that tubers sprouted earlier during storage at a high humidity than they did at a low humidity.

7. Light

Light is well known to influence the growth of plant organs, and it is a common observation that potato sprouts grown in the light are shorter and sturdier than those grown in the dark, and that they develop chlorophyll. The most intensive work on the influence of light on sprout growth is that of Wassink et al (186) who observed very considerable reductions of sprout growth by exposure to blue, violet, red, and infra-red radiations, compared with growth in darkness. In many instances, after storage for 7½ weeks at 17°C in continuous light, the average length of the longest sprouts on the illuminated tubers were less than 3 per cent of those on the control tubers in the dark. Reduction of sprout elongation by exposure to yellow and green light was marked, although not so great as it was on exposure to light of the other wavelengths. The magnitude of the effect depended upon the intensity of the radiation more particularly in the yellow and green bands: further details on the quality of the light used in these experiments were given by Wassink and Van der Scheer (187). Wassink et al (186) suggested that low concentration of chlorophyll (bound to protein) might be responsible for the inhibition of sprout elongation.

The mechanism of inhibition of stem elongation by light is little understood. The effect of duration of light exposure in an experiment on sprout-growth conducted by Headford (89) supports the view that a hormone - controlled mechanism is operative. At a constant level of radiation greater suppression of sprout elongation occurred with increase in day length. A practical aspect of this result was evident. This is that sprout elongation may be reduced more effectively by a given level of radiation when this is in continuous supply as compared with a similar level of total daily radiation which is supplied in the form of a higher intensity for a shorter period.

Bushnell (37) reported that exposing seed potatoes to light is resorted to as a means of keeping the seed tubers in good condition when it is impractical to keep them from sprouting in a dark storage. It is also occasionally adopted as a means of hastening growth of early varieties.

Ehrondorfer (61) sprouted seed tubers in the light, semi-light and dark at the same temperatures and noted that the yield with light germination was on an average of 16 experiments 12.2 per cent $\pm$ 2·1 less than the yield of the dark germination, or semi-dark germination. The depression in the yield due to pre-germination in light was mainly due to the smaller weight of the individual tubers. In the opinion of Ehrondorfer, the best pre-treatment of seed is germination in the dark. Semi-light germination must be regarded as a compromise solution between light and dark germination, but it should be kept in mind that pre-germination in dark needs perfect control of temperature, because experiences have shown that under dark conditions the sprouts of tubers grow very rapidly when the temperature rises above 50°F and often get etiolated. On the other hand, the sprout growth under light condition is relatively very slow at similar temperature, so that the sprouts do not grow to an undesirable size at planting. That is why sprouting in the light is popular all over the world.

The results obtained by Ehrondorfer have been supported by Krijthe (106) who stored potatoes during winter at temperatures, 41°, 48°, 55°, and 62°F, some in darkness, some in natural daylight, and others in constant artificial illumination. At 41°F and 48°F the growth was more vigorous in the dark, and dark storage gave an earlier harvest than light storage. At 55°F and 62°F the yield was better from light storage than from dark. It follows that exposure to light must be regulated by the temperature at which the seed potatoes are stored. Since chitting in the dark needs a fairly low temperature, which is not possible under natural condition at the later part of storage, chitting in the light is the normal procedure.

From the results of earlier work Appleman (7) concluded that subdued light does not stimulate growth in the buds on tubers with highly suberized skins; the effect is rather one of slight retardation.

The effects upon sprouting of the factors discussed above can be observed in the field, although field observations have been much extended by experiment. In addition to these more observable factors, there are others, described below, knowledge of which is wholly derived from experiment.

8. Storage Atmosphere

Storage atmosphere is considered here in the very narrow sense of atmospheres containing only those gases which are normally present in the air or are evolved by the potato.

Respiring potatoes evolve in addition to carbon-dioxide, small quantities of other volatile compounds. If these are allowed to accumulate in the storage atmosphere, they will suppress sprout growth (29, 30). Their identity is unknown, but an appreciable proportion may possibly consist of ethylene (29, 30).

9. Chemical Treatments which Influence the Dormant Period

The ability to break or prolong the dormant period at will is of great practical importance, and much work has been done to investigate chemical treatments which produce either of these effects.

(a) Stimulation of Sprouting

Some of the earliest work on breaking the dormant period of the potato by chemical means was carried out by McCallum (118), who reported successful results from a treatment consisting of exposure for 24 hours to 0.01 per cent by volume of ethyl bromide vapour and by similar concentrations of bromine, ammonia, petrol, carbon tetrachloride, and ethylene dichloride. Other vapours which have been found to give more or less successful results are ethylene (179), carbon disulphide (46), ethylene chlorohydrin (46), dichlorethylene (25), trichlorethylene (25), ethyl carbylamine (79), hydrogen sulphide (122) and methyl disulphide (122). Other chemicals can be used in solution, into which tubers or, more usually, cut seed pieces are dipped, or the tubers may be wrapped in cotton soaked in the solution. Such chemicals are hydrogen peroxide (7), sodium nitrate (145), potassium permanganate (145), ammonium sulphate (145), ferric chloride (145) and stannic chloride (145) (ferrous and stannous chloride were also effective, but may have been oxidized during the treatment to the ferric and stannic salts), sodium thiocynate (46), potassium thiocynate (46) ammonium thiocynate (46), thiorea (46), ethylene thiocynohydrin (79) (identity uncertain), glutathione (81), yeast extracts in which adenine was probably the active principle (82), ammonium dithiocarbamate (122), thiosemicarbazide (122), thioglycollic acid (122), thioacetic acid (122), ethyl mercaptan (122), thioglycol (122), various derivatives of dithiocarbamic acid (122), and ascorbic acid (103). Details of the concentrations at which the chemicals are effective have been summarised previously (28).

The substances which may be used are obviously very diverse. Stimulation of sprouting by a chemical substance does not of course mean that the chemical per se is effective, since it may act by causing the accumulation or depletion of some other substance in the tuber. An example is provided by ethylene chlorohydrin, which is believed to act by causing an increase in the content of glutathione (81). In so far as any generalization may be attempted, it appears that many sulphur compounds, and more particularly those containing sulphydryl groups, are effective in stimulating sprouting; many oxidizing agents are also effective.

(b) Chemical Treatments which prolong Dormancy

Following the discovery by Elmer (64, 65) that volatile substances produced by ripening apples would suppress the sprout growth on potatoes, it was shown (99) that ethylene, and the vapours of geraniol, citrol, ethyl alchols, and acetaldehyde, would reduce sprouting. Ethylene has also been recorded as stimulating sprouting as mentioned previously. The nature of its effect appears to depend upon the concentration. Many other chemical substances have since been shown to reduce or inhibit growth, when applied by one or other of the following methods:-

(1) In the form of vapour introduced into a stream of ventilating air, as for instance, the vapour of amyl alchol (30) and of several other alcohols (33).

(11) In the form of vapour introduced by distributing the volatile solid inhibitor among the potatoes, either impregnated on paper (50), mixed with an inert filler (143), or sprayed on to the surface of the tubers dissolved in any suitable solvent such as water (115) or dilute alcohol (171). In other instances, the chemical has been applied to the tubers in a wax coating (71). Chemical substances applied in such forms include the methyl ester of alpha-naphthaleneacetic acid (49, 50, 111, 168), iso-propylphenylcarbamate (56, 143, 196), 3-chloro-iso-propyl-n-phenylcarbamate (115), terpineol (66), alpha-chloronapthalene (66, 71), 2, 3, 5, 6 - tetra-chloronitrobenzene (25, 27, 112), 2, 4, 5 -, 2, 4, 6 - and 3, 4, 5-trichloronitrobenzene (26), the ethyl ester of 2, 4, 5-trichlorophenoxy acetic acid (114), and methylnaphthyl methyl ether (97).

(111) As a spray to the foliage of the growing plant. The most important of the chemicals applied in this fashion is maleic hydrazide (105, 113, 138).

(IV) By soaking cut seed pieces in a solution of the chemical for 1 to 7 days. This method has been used with indoleacetic acid (79).

Among the chemicals listed above Tetrachloronitrobenzene (TCNB) is widely used in Great Britain, Sweden and Australia (140). Brown (25) suggested the use of chlorinated nitrobenzene for prolonging the storage life of potatoes. The best results were obtained with 5 per cent TCNB. Nearly all treated tubers that over-wintered in clamps, covered with straw and soil had not sprouted at the end of May.

Luckwill (112) impregnated confetti paper with TCNB at a rate of 0.54, 1.35 and 2.5 grams per bushel and distributed it among potatoes in wooden fruit boxes lined with grease-proof paper. A varietal response was observed, since TCNB was very effective in inhibiting sprouting in the variety Arran Pilot, but relatively ineffective on Kerr's Pink. In England TCNB has the advantage of being much cheaper than methyl ether of alpha-naphthaleneacetic acid (MENA).

A dust containing 3 per cent of TCNB was found useful in preventing sprouting of Bintje potatoes that over-wintered in clamps made after harvest. It was applied at the rate of approximately 121 g. per bushel and results varied a little from place to place. It was important to cover the clamps with soil to prevent loss of vapour. Germination of treated tubers was not affected, and partial control of Fusarium spp. was noted (123).

Emilsson et al (67) obtained satisfactory sprout inhibition with TCNB at 2 g. per bushel. In most cases there was less rot loss from treated than from untreated tubers. Slight losses of weight, increased starch content, and unchanged cooking quality were associated with the treatment.

A dust containing TCNB applied to potatoes at harvest time in November at approximately 125 g. per bushel, kept potatoes firm and dry after 5 months of storage, prevented rots caused by Fusarium coeruleum, and prevented excessive sprouting. Treated potatoes were planted in March and gave better growth and yield than untreated seed, 10 and 9.2 tons per acre, respectively. The best results were obtained when potatoes were treated at harvest time or within 24 hours, and care was taken to avoid free air circulation for at least 4-6 weeks. In the opinion of Wassink (187), the potatoes should be aired at least one month before planting.

Glasscock (76) did not obtain successful sprout inhibition of potatoes treated with a dust containing 3 per cent of TCNB on China clay filler in autumn, when stored in clamps with a chimney at the top for ventilation.

Downie (54,55) found that a 3 per cent TCNB compound, dusted on tubers immediately after harvest at approximately 122 g. per bushel, prevented sprouting and that tubers were firm and attractive after 6 months, but germination was depressed. A varietal response was observed in these experiments, since sprouting occurred after 3 months in all varieties except Snowflake, a late variety. Weight losses were considerably reduced by TCNB on the varieties Carman, Katahdin and the late variety, Snowflake. The efficiency of the treatment seems to be associated with the length of the dormant period. After 7 months, sprout inhibition in Snowflake was still very evident.

Emilsson et al (68) found that 3.3 g. TCNB dust per bushel inhibited sprouting very effectively, whereas loss of weight and loss through diseases were significantly decreased. No significant change in taste was noted, and treated potatoes showed less tendency to darken after boiling.

Ellison (62) dusted Green Mountain potatoes with 2.7 g. of TCNB per bushel at the time of loading the bins. Treated tubers were kept in common storage at a temperature of 45° - 50°F in the fall and 35° in mid-winter, and at a relative humidity of nearly 90 per cent. After approximately two and a half months sprouting was still inhibited. The chemical was not able to inhibit sprouting after 55 days when treated tubers were exposed to free air. There was considerable sprouting in the top layer and around the edges of the treated bins, but the free air was not effective 3 inches inside the bins.

TCNB is thus very effective for treating large lots, i.e. bins of 10-20 bushels capacity, but less effective for small quantities, since practically all tubers are exposed to the air.

Ellison and Cunningham (63) found that Green Mountain potatoes treated with TCNB at 2.5 g. per bushel were in good condition after 5 months. The temperature was $60^{\circ} - 70^{\circ}F$ in the first month and $50^{\circ} - 60^{\circ}F$ afterwards with relative humidity of approximately 80-90 per cent. The per cent of infection following artificial inoculation with Fusharium sambucinum was a little lower than the uninoculated control. Similar results were obtained with the variety, Katahdin.

Cunningham (43) concluded that TCNB used as a liquid and dust treatment in amounts exceeding the dosage recommended by the manufacturers caused at the beginning an irregular wound cork formation, but a continuous layer was successfully formed, so that damage due to dry rot was not greater than in untreated tubers.

Wilson and Dawson (195) treated potatoes with a dust containing 3 per cent TCNB at the rate of 125 g. per bushel to determine TCNB residues. No toxic effect was observed on pigs or human beings.

Brown and Reavill (27) found that the repressive effect of TCNB on growth rate disappeared when tubers were removed to fresh air. Airing for about 7 weeks is required for the dusted tubers to become equal in yielding capacity to the sprouted control. A warm darkened room provided the best conditions for "rejuvenation". A period of 7 weeks for airing is contrary to the findings of Emilsson (67) who reported one month for airing after treatment with TCNB. It appears, therefore, that this period may depend upon some other factors too, e.g. the temperature and ventilation of the seed storing room.

In a previously mentioned report (4), TCNB is considered of such a low toxicity level as to be defined non-poisonous. No toxic effect was found in mice, rats, or pigs.

TCNB has been commonly used, for it has certain advantages (27, 194):

(i) It has a fungicidal effect.

(ii) Treated seed tubers are not as susceptible to frost injury as untreated control.

(iii) It is not easily volatile at low temperatures.

B. SUPPRESSING APICAL DOMINANCE

The use of low temperature storage and sprout suppressing chemicals for prolonging the dormancy in potato seed tubers has been discussed previously. From now on the role of these two factors in the suppression of apical dominance will be discussed. But before these factors will be considered it would be worthwhile mentioning in brief the mechanism of dormancy in potato tubers, because dormancy is related to apical dominance. Several theories have been proposed to explain the cause of dormancy. One suggestion that the sprouting of potatoes might be controlled by their content of growth substances came from Appleman (8). This was based on the phenomenon of apical dominance during sprouting. It was later suggested (121) that dormancy results from the inhibition of bud growth by too high concentration of auxin, although previous work (80) had indicated that the content of auxin was too low for this to be likely. Hemberg (91,92,93,94,95,96) developed a theory of dormancy of the potato in which the main suggestion was that dormancy occurs as a result of the presence of an acid-growth inhibiting substance, which disappears rapidly after harvest. This theory has been criticised (32) on the grounds that to assess a substance as a potato sprout inhibitor on the basis of its effect on Avena coleoptiles (used by Hamberg) is not justified.

Studies of the composition of tubers before and after growth had ceased, led Prunet (141) to conclude that during the period of growth the nutritive substances are uniformly distributed throughout the tuber, but after full size has been reached there is a movement of these substances towards the vicinity of the apical buds.

The foregoing facts (9) apply only to whole tubers. If the tubers are cut transversely into halves and allowed to sprout under like conditions, a very different situation is revealed. With the suppressing influence of the terminal eyes removed, the eyes on the stem end show an equal, if not a greater capacity for the production of vigorous sprouts. This does not mean that all the eyes on the stem half will produce sprouts. Usually one or two vigorous sprouts will grow out near the terminal end of the half and check the growth of the remaining buds. In this capacity, they act as terminal eyes for the stem half. If the tuber is cut into transverse slices which removes the entire inhibiting action of the terminal eyes, there is a general sprouting over the entire tuber, depending upon the thickness of the slices.

If tubers (9), before the end of the rest period, are cut transversely into halves or slices and placed under favourable growing conditions the basal buds will grow out first. If, on the other hand, the tuber is cut lengthwise into fractions, the basal buds remain latent and the terminal buds do not start until sometime after the basal buds on the transverse sections have grown out. It appears that the basal buds have a shorter rest period but their growth is inhibited by the terminal eyes even before their buds begin to grow.

All these facts show that internal inhibiting influences play an important role in the production and growth of sprouts on potato tubers. For this reason they must be given consideration in formulating a rational procedure for cutting the tuber for seed.

The statement (9) is frequently made that the seed end of the tuber contains the stronger eyes, and for this reason the tuber should be cut lengthwise. This idea is the result of observations made on the production of sprouts from whole tubers, in which case, of course, the terminal eyes grow out first, and grow more vigorously. It has been noticed that the eyes on the stem end will produce just as vigorous sprouts as the terminal eyes if their connection with the terminal eyes is severed. The greater vigour of sprouts on the stem halves may be due in part to favouralbe location in respect to external factors, since these sprouts are usually located near a cut surface. A chemical study of the stem and seed halves just at the end of the rest period showed, in many cases, a greater metabolic activity in the stem half. This half always contains more soluble carbohydrates and greater diastase activity. This clearly disproves the older statement in the literature that the buds on the stem end do not grow out on account of the lack of available soluble carbohydrates.

From these observations and experiments on the growth of sprouts from different parts of the tuber, it is logical to conclude that most of the eyes of the tuber are of equal value for seed purposes.

Relation of Apical Dominance to Sprout Vigour

Apical dominance (16) in potato tubers is pronounced only with the first crop of sprouts, and then only when the terminal sprout or sprouts are vigorous and not checked in their normal growth. After potato tubers mature, they go through a period of dormancy (35,104,121). If the storage temperature at the end of this is high enough, the seed tubers tend to produce a single sprout, usually at the apical end, which suppresses the growth of other sprouts. This is known as the apically dominant or single sprouting phase, and normally occurs during the autumn. Not all the varieties respond alike to this treatment as reported by Stuart (167). In the variety Rural, for instance, the only eyes producing sprouts are those of the seed end whereas in the case of Green Mountain, lateral eyes are just as likely to start into growth as the terminal ones. When the temperature is too low for sprouting to occur, the tuber passes out of this phase, and the number of sprouts it will eventually produce tends to increase with advancing age. If sprouting is delayed until late in the winter, the seed may have reached the multiple sprouting phase and often produces several sprouts per set. The details of the review of literature on this subject are given in the next section. Anything that will cause the tubers to produce weak sprouts will at the same time destroy the dominance of the terminal sprouts. In other words, there is a direct relationship between the vigour of the sprouts and the degree of apical dominance. This relationship may be illustrated by the following three typical cases of weak sprout growth:

(a) Weak Sprouts Caused by Long Periods of Cold Storage

Appleman (10) placed McCormick potatoes on March 7th. in a commercial storage house at a temperature of 33° to 34°F. The first lot was removed from storage on September 25th. after nearly six months storage, and planted in moist sawdust in the greenhouse. Tubers showing the typical sprout growth of the lot were taken up and photographed on October 18th. The second lot were removed from cold storage on February 20th. after about twelve months storage, and planted in the greenhouse in the same manner as lot one. Typical tubers were taken up and photographed on March 25th. It should be noted that the sprout vigour is greatly reduced after long periods of cold storage, and as this vigour becomes less, the number of sprouts multiply and are scattered over the tuber. For our present purpose it is immaterial whether the very weak sprout growth on the tubers stored twelve months was due to the effect of a low temperature or to the unusual age of the tuber. The capacity of the tubers to produce vigorous sprouts was lost and at the same time the apical dominance disappeared. The vigour of the sprouts on the tubers stored for six months at low temperature was considerably below normal and the degree of apical dominance was considerably reduced.

(b) Weak Sprouts Caused by Repeated Removal of Sprouts

Appleman (10) sprouted seed tubers under growing conditions and removed the sprouts from the tubers a number of times, until a point was reached when the sprouts of the succeeding crop were very weak and scattered over the entire tuber. The disappearance of apical dominance was concurrent with the appearance of weak sprouts. The effect of weak sprouts growth on the subsequent development of crops will be discussed in greater detail under a separate section of the review of literature.

(c) Weak Sprouts Caused by Sprout Suppressing Chemicals

Much has been said about the use of sprout suppressing chemicals in prolonging the dormancy in potato tubers. The following paragraph will illustrate the role of some chemicals which have been effectively used in destroying apical dominance. Not very much work has been done on this line. Since there is a movement of growth promoting substances (high concentrations of auxins) toward the vicinity of the apical buds (120), which may result in apical dominance, it seems feasible that there would be some chemicals which would inactivate growth inhibiting substances (i.e. high concentration of auxins) and thus suppress apical dominance and bring about multiple sprouting. According to Hayward (88), polar growth of the rhyzome axis ceases at the onset of tuberization which is followed by lateral proliferation of storage tissues. Since the potato tuber is an enlargement of some portion of the rhyzome, it seemed feasible that the auxin mechanism postulated for apical dominance of tubers might also apply to polar tuberization of rhyzomes.

In this respect, Michener (121) suggested in 1942 that auxin inhibits bud growth in dormant tubers and removal of auxin by ethylene chlorohydrin permitted growth to proceed. Black (19) also contended that low concentrations of auxin enhanced cell division and elongation whereas high auxin concentrations inhibited growth. In essence, a critical auxin level is proposed. Accepting the critical auxin concept as a premise, a chemical which antagonizes the growth-promoting effects of auxin should be useful in evaluating whether polar tuberization is associated with auxin gradients in the rhyzomes. Concurrent with this view, Bonner and Bandurski (20) have indicated that 2,4-dichloranisole and 2,3,5-triodobenzoic acid antagonize auxin, although they report that 2,3,5-triodobenzoic acid does have some growth promoting properties.

Another fact seemed deserving of consideration. Snyder (16) and Thomson (173) concluded that treating meristems with growth-substances may cause enlargement or displacement of primordia resulting from mobilization of anabolic products such as carbohydrates and proteins toward location of treatment. Further support is given to this theory by the fact that applications of certain growth substances will alter the single ear-producing pattern of certain single-cross corn varieties (73). The intrisic cause of this effect remains unsolved.

Some of the sprout suppressing chemicals have been effectively used to destroy the apical dominance when applied as a foliar spray. For example, maleic hydrazide (pre-harvest faliar sprays) (138) caused apical dominance to disappear.

The work of Denny (47), with Bliss Triumph potatoes, demonstrated the possibility of suppressing apical dominance by the use of various chemicals; notably thiourea and potassium thiocynate. Tubers treated with various aqueous solutions of these chemicals also exhibited a marked tendency toward multiple sprouting.

Eastman (60) reported that the treatment of seed potatoes with thiourea (one hour soak in a one per cent solution) resulted in a significant increase in the number of stems per hill, number of tubers per hill, and yield of tubers of one-and-a-half to two-and-a-quarter inches in diameter. The treatment also caused a slight increase in total yield especially in the variety Katahdin.

Steinbaur (162) reported that certain chemicals such as ethylene chlorohydrin, several thiocynates and thiourea break this inhibiting effect, allowing more of the buds to develop. In Steinbaur's opinion thiourea is very effective in causing more than the usual number of sprouts to develop per eye and per seed tuber.

C. SPROUTING SEED POTATOES AND ITS SIGNIFICANCE IN THE PRODUCTION OF THE POTATO CROP

The practice of sprouting seed potatoes (171) before planting in order to hasten the development of marketable tubers, is one that is commonly employed by growers of early potatoes in Great Britain and on the Continent, but is little used by American growers.

Sprouting (162) consists of spreading out the seed potatoes in a single layer, in such a way as to allow a small amount of light to reach the tubers. The barn or ware house floor or special racks may be used for this purpose. After two or three weeks the tubers will have turned green, and short, tough sprouts will have developed.

Various terms for the practice of sprouting seed potatoes before planting have been used by several authors. Greening or green-sprouting (86); green-sprouting (10,60,86,93); sun-sprouting (84); greening and germinating or sprouting seed potatoes (167); are some of the common terms used.

The British growers (167) use a special seed tray or flat, constructed with corner posts from four to five inches higher than the sides, to which a narrow strip or board is nailed across the upper end. This strip serves as a handle in lifting or moving the flats and, when tiered one above the other in the germinating room or house, provides an open space between the flats. The dimensions of the tray are immaterial, except that it should be of a convenient size to handle. A tray having an outside dimension of 16by 30 by 3 inches has been found to be very convenient to handle. The primary object of the flats is to furnish a convenient receptacle for the selected seed tubers, in which to expose them to light and sufficient heat to produce slow growing, but vigorous terminal sprouts. By placing the seed end uppermost it tends to stimulate the development of strong sprouts from the bud eye clusters, which in the presence of light, remain short and stubby and are not easily broken off. Many of the British growers place their seed in the trays in the autumn or early winter. Under favourable conditions a short and healthy sprout will be obtained in from four to eight weeks, depending on the season of the year in which they are placed in the trays. Not all the varieties respond alike to this treatment.

When shallow trays are not available it is possible to sprout the seed tubers by spreading them out rather thinly on a floor or the ground (167) where they can be protected from frost and at the same time be exposed to light during the daytime. By turning over the tubers every four or five days with a wooden rake or a potato scoop shovel, most of the tubers will be exposed to the light during some portion of the germinating period. Two or four weeks exposure will usually be enough to start germination sufficiently to enable the one who cuts the seed to select those eyes that show an active growth.

The benefits derived from sprouting the seed before planting it are not confined to the securing of a better stand and quicker maturity, but it is claimed that a heavier yield is also obtained. Several investigators (10.24,36,37,60,77,83, 84,85,86,119,162,172) have reported increased yields and earliness resulting from sprouting seed potatoes prior to planting. The following are some of the findings:

Greig (77) reported increased yields from sprouted over unsprouted seed of from 34 to 39.5 bushels per acre. Still larger increases were mentioned in which an increase of from 61.6 to 74.7 bushels was obtained (3). Davidson (45) reported that sprouting the seed increases the yield by from 30 cwt. to 2 tons per acre in an average season. Eastman (60) found that a combination of sprouting and thiourea treatment would be practical for seed potatoes which required to be early harvested. For commercial seed growers, he reported, the thiourea treatment alone would be a practical way to obtain larger yields of tubers in the size range desired for seed, as the chemical stimulates sprouting.

Hardenburg (85) studied extensively the beneficial effects of sprouting and reported that its effect on tuber set and yield is rather marked in two varieties, which he worked on. In his opinion sprouted seed developed a higher tuber-set than seed not treated because of a shortening of the internodes and a corresponding increase in node number on the undergrown portion of the stem.

Hanlan (83) reported that the resultant crop from sprouted tubers of the variety Irish Cobbler was ready for use twelve days earlier than that from unsprouted tubers, and also that an average increase in yield of 44 bushels of marketable potatoes was obtained at full maturity of the crops. With the variety Green Mountain, nine days in earliness and 31 bushels per acre in yield were gained from the sprouted tubers. In the opinion of Hanlan it may be concluded that the sprouting of tubers for six weeks prior to planting will not only materially shorten the period from the time of planting to date ready for use, but will also give a very tangible increase in the yields obtained.

McCubbin (119) showed that plants of sprouted tubers came up first, those of desprouted tubers emerged next and those of dormant tubers appeared last.

Puscharew (142) found an early plant emergence and flowering as a result of sprouting seed tubers. He also noted that the shortening of the day (six hours) during sprouting of the seed, caused in all cases, earlier ripening of the plants and earlier tuberization than chitting in twelve hours of light.

Bushnell (36) working with the variety Russet Rural, which was harvested in November found a gradual increase in multiple sprouting as a result of exposure to light in a greenhouse at later dates. Results from these samples placed out to sprout at different dates showed not only an increase in degree of multiple sprouting at successive plantings but also that on any given planting date the sprouting of these samples was practically identical. On June 28th. for instance, tubers sprouted for 16 weeks, beginning March 8th. produced almost exactly the same number of sprouts as those chitted from May 3rd, only 8 weeks. In this experiment, therefore, the length of time the tubers were exposed to light was a negligible factor in the character of sprouting.

In connection with studies pertaining to the relation of age of tubers to their type of sprouting under field conditions (36) the question arose as to what number of plants per hill would produce the highest yield. The following table quoted by Bushnell (37) gives an example in which he concluded that two to four plants per hill gave the highest yield of tubers over $1^7/_8$ inches diameter, but the number of tubers per hill increased with the number of plants per hill. Growers ordinarily do not think in terms of plants per hill, but are well aware that the distance between the hills affects the average size of the tubers.

Table - Data on Russet Rural Potatoes Grown on Silt-loam at Wooster, Classified According to the Number of Plants per Hill

Plants per Hill	Yield per Hill (lb)			Size A Tubers		Hills in each class
	Size A*	Size B*	Total (lb)	No. per hill	Av. Wt. (lb)	
1	1.32	0.15	1.47	4.69	0.281	32
2	1.62	0.32	1.95	5.21	0.313	51
3	1.55	0.43	1.96	5.40	0.283	15
4	1.40	0.55	1.95	6.00	0.233	2

* Size A tubers are those retained on $1^7/_8$ inch screen, Size B are those from $1^7/_8$ to $1\frac{1}{2}$ inches seed.

Shotton (156) sprouted three varieties, Arran Pilot, Majestic and King Edward in two environments, a barn store and a glass chitting house. For the main crop varieties King Edward and Majestic, the differences were very small. With Arran Pilot, there was a marked advantage from sprouting in the barn store rather than in the glasshouse. Seed stored in the glasshouse was trayed on arrival from Scotland in December, and allowed to sprout at will, care being taken to ensure that night temperatures did not fall below 35°F. Seed sprouted in the barn store was also trayed on arrival, following Dutch practice, it was held below 40°F (at which temperature no visible sprout growth takes place). Until February 1st, when the temperature was permitted to rise to 50°F, the lights were switched on for ten hours daily and sprouting was allowed to begin. The possibility that this shortening of the sprouting period, rather than any inherent superiority of the barn store, might be beneficial to Arran Pilot was suggested by the fact that seed kept cool in the store until February 1st. and then placed in the glasshouse also outyielded, by 2½ tons per acre, seed which had been stored from December in the glasshouse. In the experiment Shotton found that when planting took place at the end of March, Arran Pilot seed which had not been allowed to start sprouting until March 1st. gave a higher maturity yield than seed which started sprouting on February 1st. With Majestic, the results were quite the reverse, the longer sprouting period giving the highest yields. It appeared that this variety should be started in December. King Edward appeared to need a longer period than Arran Pilot, though possibly not quite so long as Majestic.

It should be pointed out here that sprouting from February or March, which give multiple sprouting, may not be beneficial to the early potato grower, who is interested in bringing forward the date of lifting, and thus increasing the possibility of obtaining a higher price. The early grower will therefore, sprout their seed throughout the storage period to obtain apical dominance.

Thomas (172) reported that the average results of 1,465 experiments on the effect of sprouting on the yield of main-crop potatoes, carried out in Ireland during the thirteen years 1903-15 were as follows:-

Yield per acre from sprouted seed 12 tons 5 cwt.

Yield per acre from unsprouted seed 10 tons 6 cwt.

In his text book, Thomas also mentions that a heavier yield is obtained from potatoes with the single sprout than from potatoes with several sprouts. Not only, he says, does the single sprouted seed give a heavier yield earlier, but it also gives fewer unsaleable tubers - (chats) than multi-sprouted potatoes.

Not much work has been done on the influence of the number of sprouts at different sprout length levels on the yields and grades of potato tubers. An experiment was carried out in

1953 by Heile (90) at Holland to determine whether more selective sorting (according to weight, length of sprouts and number of sprouts) of stock seed potatoes of a given riddle size, might lead to a reduction in the variation in the size of seed potatoes grown from the stock seed. Bintje stock seed (Class A) potatoes of the 35-45 m.m. grade were used. They were first sorted into three classes according to weight 35-45 gms., 45-60 gms. and 60-80 gms. Each of these classes was sub-divided into three sub-classes according to sprout length 0.5 - 1.5 cm., 1.5 - 4 cm. and 3 - 7 cm. The differences in sprout length were artificially induced by subjecting a portion of the potatoes to dark treatment. Each sub-class was further sub-divided into two groups according to number of sprouts per tuber. Thus the potatoes were finally sorted into 18 categories. They were planted at a distance of 60 x 40 cm. A control crop was grown from unsorted stock seed. Of the three factors tested (weight, sprout-length and number of sprouts per tuber), weight had the greatest influence on total yield and on yield of tubers of seed size (28-45 mm). The 60-80 g. class have a 10 per cent higher yield and a 20 per cent higher yield of seed sized tubers than the 35-45 g. class. Corresponding figures for increases given by 0.5 - 1.5 cm. sprout length class compared with the 3-7 cm. class were 7.5 and 6.0 per cent respectively. Differences in number of sprouts per tuber had no marked effect on yields of seed-size tubers but there was a greater proportion of seed-size tubers (75.2 compared with 72.3 per cent) in crops from stock seed, with the greater number of sprouts per tuber than in crops from the seed with the smaller number of sprouts. The percentage of tubers of seed size yielded by the 45-60 g. and 60-80 g. classes of stock seed was greater than that yielded by the unsorted control. Headford (89) found that above a certain length of sprout (2.0 cm.), the longer the sprout the greater the reduction in the relative growth rate of the plant from it. This confirms the results obtained by Heile as discussed above.

Toosey (177) working on the control of sprout number suggested that a great effect on the number of main stems and tubers was exerted by varying the number of sprouts per set. As the number of sprouts per set increased there was also an increase in the number of main stems and tubers produced per hill, i.e. growth from one set. With this rise in main stem or 'true plant' density per hill the vigour of the individual stems and the size of tubers became increasingly restricted as a result of the greater intensity of competition developed within the hill. The optimum number of sprouts per set depended on variety, the condition of growth, and the size of tubers required for the market.

Thomas and Eyre (172) recommended the use of single sprouted seed for early production, but advised that tubers bearing several sprouts should be planted for the production of a seed crop. With respect of main crop varieties, notably King Edward and Stormant 480, which tend to produce an excessive proportion of small tubers, experiments have shown that when sprouted seed is used the quantity of ware in such varieties may be greatly increased by reducing the number of sprouts per set (176). On the other hand, in such varieties as Majestic, which are inclined to produce an excessive proportion of large coarse tubers under fertile conditions, it would seem advisable to use sets with several sprouts.

A further experiment conducted by Toosey (177) was undertaken in 1960 to study the effects of sprouting treatment, seed size, spacing and date of planting on tuber number, size and yield of the variety King Edward. Early sprouting gave fewer sprouts per set and hence plants per hill than late sprouting. The number of tubers produced was directly related to the number of plants. Sets with fewer sprouts (plants) produced fewer tubers than sets with many sprouts. Small seed produced fewer plants and hence tubers than large seed. The size of tuber was inversely related to tuber numbers. Early sprouting, small seed and wide spacing increased tuber size, but early sprouted seed planted closely gave a higher yield of ware than late sprouted seed planted further apart. Tuber numbers and yields were increased by early planting.

Experiments at the North of Scotland College of Agriculture (1928 to 1939 inclusive), have shown that the use of sprouted seed has produced a marked improvement in the yield of ware. Dyke (59) calculated that the sprouted seed in the trials at Craibstone outyielded the unsprouted seed by an average of 1.7 tons per acre for planting in March and by 2.5 tons per acre for planting in Mid-April. He noted considerable variations between one season and another. Dyke mentions that under Craibstone conditions for chitted seed, there is a period of at least a month from mid-March to mid-April in which variations in date of planting have little average effect. There are, however, differences between years, most years showing some gain from planting before mid-April but a few showing losses of a ton or more (with one case in 1942 of a loss of over 6 tons) from early planting. For unsprouted seed, on the other hand, there was a general slight gain from planting at mid-March or early April with serious losses from early planting in a smaller proportion of years (the worst in 1942 being a loss of 4.5 tons per acre).

The sprouting of early varieties of potatoes has been for many years generally accepted as a profitable practice. Recently the practice has been adopted in main-crop production, In the Eastern Region of England, in 1948 the majority of earlies, but only about 10 per cent of main-crop potatoes, were sprouted; by 1958 the latter figure had risen to about 38 per cent (44).

The main benefits derived from the use of sprouted seed potatoes are related to the earlier bulking of the crop. This would in turn bring ware potatoes to the market earlier, to fetch a good price. Although sprouting does increase the yields of crops, Dyke (59) stated that in a trial with Majestic at Rothamsted in 1945, sprouting showed little benefit when the seed was planted early. He suggests that in the absence of adequate information on sprouting, a satisfactory increase in yield might be obtained by encouraging early planting without asking farmer to provide expensive chitting houses for their seed potatoes.

One of the great problems that arises in sprouting is the space it requires and the control of temperature and light. A glass chitting house costs about £17 to £25 per ton of seed which seems high, and it is impracticable to use it for other purposes. During recent years a technique of sprouting has been developed using artificial light instead of daylight. With the aid of fluorescent lighting, almost any building which can be made frost proof may be adapted, and the increase in the practice of sprouting over the last ten years can be closely correlated with the extension in the use of this method (44). Its main advantage is the saving in capital costs: the cost of building conversion and installation is estimated to be from £6 to £12 per ton. The fluorescent light tubes are found to be very suitable in meeting light requirements, in that they are cool running and give uniform illumination. With a tube colour of 'warm white' an appropriate quality of light is provided both for greening and for controlling sprout length.

On the basis of present day recommendations the lights are usually switched on for 8 to 12 hours in each 24, although longer periods of light up to continuous illumination may be used where sprout growth is very rapid (5). The number of light units required are calculated on the basis of one strip unit to 6 stacks of trays for earlies or one to 8 stacks in the case of the main crop: the units require to be moved daily in order to equalise the lighting of each tray. Some farmers prefer to instal more units to avoid making the daily change-over. With respect to the amount of light required for sprouting, the results of modern work indicate that provided sufficient light is given to prevent etiolation the period and intensity of illumination have no significant effect on subsequent crop development (89,143).

A recent development in building construction is the introduction of a design by Hollinrake (98) for a special purpose sprouting shed. Its main features include an insulated roof, glazed walls and the provision of ventilating ducts and a fan arranged to give ventilation with outside air or internal air circulation. The cost of such a building would be about £28 to £30 per ton of seed. This bears reasonable comparison with that of a glass chitting house, and the design would allow a greater measure of temperature control.

D. THE INFLUENCE OF SPROUT REMOVAL ON THE DEVELOPMENT AND YIELD OF POTATOES

Before discussing desprouting further it is essential to consider the immediate physiological effect of desprouting of the seed tuber.

Physiological Condition of Seed Tuber

Physiological changes (194) occur during the period of storage following desprouting. Losses in weight due to respiration, loss of water and sprouting are collectively known as shrinkage. Respiration causes a relatively small proportion of the total shrinkage and can for practical purposes be ignored. Loss of water occurs firstly through wounds received during harvesting, until such time as these have healed, secondly through the lenticels or breathing pores of the tubers, and thirdly through the sprouts, the last named being, in the later months of storage, by far the most important source of loss. Sprouting causes shrinkage in two ways: firstly by removing stored food material from the tubers, and secondly, as indicated above, by increasing water loss.

Boswell (22) studied the effects of five successive desproutingson the condition of the tuber. Here he selected twenty-five tubers of each size, such as 5, 10, 15, 20, and 30 g. Most of the 5 g. and over half of the 10 g. and 15 g. sized tubers decayed between the fourth and fifth desprouting.

Practically no losses from decay occurred until after these crops of sprouts had been removed, and these losses were almost entirely in the 5 g. sized tubers. Upon harvesting the fifth crop of sprouts, the tubers appeared to be so nearly exhausted that the study was terminated. Cutting a large number of tubers showed them to be pithy and to contain large hollow space surrounded by semi-dry pithy tissue.

Removal of successive crops of sprouts (22) of the potato tuber are known to have a pronounced effect upon the number, size, and vigour of sprouts; upon the number of stalks per hill; and finally upon the yield and market quality of the crops.

(a) Upon the Number, Size and Vigour of Sprouts

Appleman (10) conducted an experiment to test the effect on sprout vigour by removing several crops. It was necessary to find a reliable means of comparing the sprout vigour of the different crops of sprouts removed from the tubers. The quotient of the average weight of sprouts in grams divided by the average length in centimeters was used for this purpose. This quotient (10) is a safe and fairly accurate index of relative sprout vigour if the sprouts are not over two inches in length and the sprouts have been produced under nearly the same conditions.

In the first crop of sprouts, the apical dominance was pronounced, as the very large tubers produced only two or three sprouts, while the medium and small tubers produced only one sprout each. With each succeeding crop, the number of sprouts increased irregularly until there was a rather sudden burst of sprouts over the entire tuber. When this occurred, the tubers failed to produce another crop of true sprouts, but instead they produced a number of small tubers. After the first and second crops of sprouts were removed, the index of sprout vigour remained fairly constant for the next four crops and then took a sudden drop with increase in the number of sprouts.

Bushnell (36) stored two lots of tubers in a dark box in a warm greenhouse. One lot stored throughout March and April in this box and desprouted three times during the two months, produced 3.58 sprouts per cut piece when planted on May 4th., the other lot stored for but one month in the box and desprouted once, produced 3.44. The seed tubers held dormant averaged 1.82 sprouts at this planting. Warm, dark storage for one month with one desprouting thus about doubled the number of sprouts, and an extra month of warm storage gave practically no additional effect.

Krijthe (109) and Headford (89) also reported an increase in the number of sprouts as a result of killing or removing the first sprouts. Taylor and McDermott (169) have reported an increase in the number of main stems (and hence tubers) from tubers desprouted about two weeks before planting.

(b) Upon the Number of Stalks and Yield of Tubers

Another experiment, also conducted by Appleman (10) was to test the effect on yield of removing the sprouts from small tubers which were planted whole. When the apical dominance was destroyed by removing the sprouts and the tubers were planted whole, a high percentage of culls (chats) resulted from too many stalks per hill. Home grown Irish Cobbler were placed in a vault soon after digging on August 2nd. When they began to sprout, fifty-four tubers of the same size, and each bearing one vigorous terminal sprout were carefully selected and divided into three lots of 18 tubers each. Lots one and two were sprouted as indicated in Table A below. The third lot was planted with the first crop of sprouts attached.

The yields are given in Table B.

Table A - Date on Removal of Sprouts from Seed Tubers

No. Lot	Date of Sprout Removal	No. of Tuber	Av. wt. (oz) per Tuber	Total No. of Sprouts	Total wt. (g) of Sprouts	Index of Sprout Vigour
1	Feb.25	18	3.5	31	14.91	0.241
1	April 4	18	3.5	82	10.75	0.124
2	April 4	18	3.5	66	41.90	0.325

N.B. Lot 1 was desprouted on 25th. February and 4th April, while Lot 2 was desprouted on 4th. April.

Table B - Crop Yield as Affected by Removal of Sprouts from Seed Tubers as Indicated in Table A

No. Lot	Tubers Planted With	Av. No. of Tubers per Hill	Av. wt. (oz) per hill			
			Total	No. 1	No. 2	Culls
1	Second crop of sprouts removed	15.7	17.6	3.8	8.6	3.4
2	First crop of sprouts removed	12.3	15.3	5.5	6.8	3.0
3	First crop of sprouts attached	12.8	17.6	9.5	5.5	3.0

McCubbin (119) kept seed potatoes in the light and in the dark in controlled storage at approximately 50°F for the last month of storage. Some of the tubers were planted with the sprouts attached, while others were planted with sprouts removed. Similar tubers were stored under similar conditions for the last month at 36°F. He noted that plants of sprouted tubers came up first, those of desprouted tubers emerged next, and those of dormant tubers appeared last. Ten plants of each treatment were harvested at seven day intervals beginning 43 days after planting. He found that plants of sprouted seed produced more tubers, than did those of dormant seed. Plants of desprouted seed produced markedly more tubers than did plants of the other two treatments. The larger number of tubers produced by the desprouted seed appeared to be due to the larger number of stems per seed tuber, resulting from the desprouting operation. Yield in weight of tubers was larger from the sprouted seed than from the dormant seed, although the differences were not statistically significant in any of the comparisons. The yield in weight of tubers from desprouted seed were intermediate, except at the final harvest when yield from this treatment tended to be greater than from the other two treatments. No evidence was obtained indicating that seed tubers exposed to light were better than those maintained in darkness, if the conditions of temperature and relative humidity to which the tubers were subjected were the same.

McCubbin (119) conducted another similar experiment and noted that sprout removal decreased apical dominance and increased the number of stems per seed tuber. Desprouted seed tubers usually produced a larger number of stems, from the point of desprouting onward, than that which existed prior to removal of sprouts as shown in the table overleaf.

Table - Influence of Sprouts on Number of Stems per Plant - (Tubers Sprouted May 6th. to June 5th. before Planting)

Treatment	Storage Treatment					
	Stored in Light			Stored in Dark		
	Sprouted	De-sprouted	Dormant	Sprouted	De-sprouted	Dormant
Stems per plant (Mean of 70 plants)	1.67	2.46	1.21	1.78	2.70	1.26

Desprouted seed had significantly more stems per seed tuber than dormant seed as shown above, and tended to produce more tubers. This is in agreement with results reported by Boswell (21) and Smith (158). No markedly significant differences (158) existed in the number of stems per seed tuber as between light and dark stored seed.

Westover (191) reported that the practice of removing sprouts from stored seed potato increased the loss in storage from decay, reduced the stand of plants in the field and lowered their vigour and decreased the yield of prime tubers and total yield. In his experiment Westover desprouted five times and found that the removal of sprouts once, tended to cause a reduction in the yield of prime potatoes and the total yield, not sufficiently, however, to be significant. When the sprouts were removed two or more times the reduction in yield was significant.

Recently Germann (74) carried out experiments on the influence of desprouting on germinating power and yield, with tubers of the varieties Vera (first early) and Olympia (early main-crop). An unfavourable influence on the yield by desprouting happened only after the germ power of the tubers had diminished. Hartman (87) also supporting this view, suggested that, because of loss of some substances when the first crop of sprouts was removed, and because of consequent slower growth in the field and early senescence, the yield of crop was diminished.

In another experiment Germann (75) selected 12 potato varieties and stored them from December to May in the dark at 12°C. Sprouts were removed at 4 weekly intervals and the consequences of desprouting were observed. The results obtained showed that the sprouting ability in very early and early varieties was weakened earlier than in medium - early or late varieties. A chitting period (4 weeks in daylight and a temperature of 12-18°C) inserted between sprout removal and renewed sprouting, improved sprouting ability. This improvement was evident in the reduction in the number of "blanks" in the field caused by disturbances to growth which followed planting immediately after desprouting. The growth disturbances were caused by Rhizoctonia infection or by small tuber formation on the sprouts. Sprout removal caused yield reductions only if there was a permanent weakening of the tuber. The author concluded that provided the storage conditions are similar, and that the same total weight of sprouts is produced during a given period of time, desprouting three times does no more injury than desprouting once. There was a positive correlation between the weight of sprouts removed (determined in the laboratory) and tuber yield. The reduction in the sprouting energy as a result of continued sprout removal was not accompanied by a reduction in respiration rate.

The practice of desprouting seems to be beneficial if the aim of the grower is to increase the proportion of seed sized tubers. The evidence described above, shows that the total yields are not affected if it is done two or three times under favourable storage conditions. An adverse condition such as high temperature and darkness, on the other hand, may influence the seed tubers to rapid sprout growth with a considerable loss of stored food, and hence a severe reduction in the yield of the crop. Boswell (22) mentioned that the number of desproutings would always depend upon the size of the seed tuber. He said that even though there be an abundance of known food materials in a small tuber (5 to 10 g. for example) such a small piece will not produce a good vigorous sprout because of an insufficient supply of some unknown, essential, growth-promoting substance, and that a piece of perhaps 20 to 30 g., is necessary to supply enough of this substance to support good sprout-growth. Large tubers possess such an ample supply of stored foods and growth-promoting substances as to support good sprout development after four sprout removals, while the samll tubers become much depleted.

E. EFFECT OF SEED SIZE AND SPACING ON THE DEVELOPMENT AND YIELD OF THE POTATO CROP

The influence of size and character of seed, and spacing upon the resultant potato crop have been subjects of experimental study by numerous investigators for many years. A rather complete review of the early work on this subject is presented by Stuart et al (164) in the United States Department of Agriculture Bulletin No. 1248. A few of the more recent reports of work on these subjects are by Bushnell (37), Bates (17), Le Clerg (110), Smith et al (159), and Wakankar (184). In general a review of the literature on size of seed indicates that as the size of seed increases the resulting plants are more vigorous, have more stalks and more tubers per hill, and usually produce a larger total yield. The following are some of the results obtained by the above mentioned authors and others, on the effects of seed size and spacing on the yield.

(a) Effect of Seed Spacing on Potato Yields

Chucka et al (39) in a review of the literature of experimental work on seed spacing (6,9, 12 inches) showed in general that the closer the spacing the larger the number of plants and tubers and the smaller the average size of the tubers produced. This is of particular interest to seed growers all over the world, because of the increasing demand in recent years for seed potatoes of smaller average size. Thus a seed grower would like to know what spacing will produce the most profitable yield of medium sized tubers.

Stewart (163) reported that thick planting (6") outyielded thin planting (15") by 34,884 tubers or 49.3 bushels per acre. This increase in favour of thick planting was all in the two smaller grades of tubers. In fact, in the largest grade, thin planting fave the larger yield by 42.1 bushels per acre. Either for seed or for table use, the crop from thick planting was decidedly superior to that from thin planting because of the smaller number of very large tubers in the former. The average weight of tubers above two ounces was 4.75 ounces for thick planting and 6.16 ounces for thin planting. In the 2 to 12 ounce grade, thick planting outyielded thin planting by 74.7 bushels per acre.

Terman (170) reported an increased number of tubers per hill with an increase in spacing of the seed tubers, but the total yield was always greater at closer spacing than wide spacing. It was observed, however, that the stem branches less at close seed tuber and row spacings than at wider spacings.

Claypool (41) also found an appreciably consistent increase in the number of tubers produced per hill as the plants were spaced farther apart. The tubers also increased in size as the planting distances became further apart.

(b) Effect of Seed Size on Potato Yields

Numerous experiments (37) on the rate of planting potatoes have shown that increasing the size of the seed tubers increased the average number of plants per hill. The increase in plants to the hill, in turn, increased the number of tubers per hill, and although the average size of the tubers was reduced, there was usually an increase in yield. Appleman (7) studying the decline in apical dominance noted that, as the number of sprouts increased, the individual sprouts were less vigorous.

Aicher (1) reported that as the size of seed was increased, the number of stalks per hill and the total yield per acre were increased. He concluded from this that large seed was better than small seed, under equidistance of planting, only because of the greater weight of seed.

Rosa (144) also reported an increased yield due to the increase in size of tuber. Also the percentage of culls (chats) increased proportionately. The following table gives the information.

Table - Yield. Size of Seed Tests, Spring Crop
(Early Ohio Variety)

Wt. of Seed	Yield (Bushels per Acre) of Potato Crop		
	Bu. No. 1	Total	P.C. Culls
20 g.	43.4	55.0	21.2
30 g.	75.0	97.7	23.3
40 g.	81.0	108.0	25.1
50 g.	80.0	113.4	29.4

Salaman (150) studied the influences of nine classes of seed tubers (which ranged from 0.35 oz. to 4.0 oz. in weight) on the character and yield of the potato. In his experiment, he planted seed tubers at a distance of 12 inches in drills of 32 inches spacing. He concluded:

(1) The larger the seed tubers the greater the gross crop they produce.

(2) The size of the gross crop diminishes with diminuation of the size of the seed tuber, at first gradually, then more rapidly.

(3) The proportion of useful heavy ware in a crop bears a very definite and close inverse relation to the weight of the seed tuber.

(4) As a result of the above it does not follow that the heaviest seed produces the most valuable crop. On the contrary the heaviest net return actually obtained was from seed weighing 1 oz.

(5) In estimating the monetary value of a crop this relationship is of great importance, as is also the money spent per ton on seed.

(6) Allowing for the variation - which is not high - of the ware production of any given class as well as that of the gross crop, it may be taken that a seed weight of about 1.5 ounces is the best for the production of a crop of the heaviest monetary value.

Salaman, therefore, suggested that the amount of food material in the parent tuber is an influencing factor in that the larger the parent tuber, the greater is the initial food supply to the growing plant. In this connection Denny (48) has also shown that the amputation of the parent tubers at different growth stages of the potato plant reduced the total yield, if the amputation took place before the plants were 10 inches high, thus emphasising this importance of stored food materials of the parent tuber on the growth of the potato plant in its early stages.

Wakankar (184) in opposition to the above theory of Salaman presented his view in a different way. He conducted an experiment with three sizes, viz, 10, 20, and 40 g., and germinated in sand. Only one sprout was allowed on each seed tuber in this test and the extra sprouts were removed. They were then planted as usual in 12 feet one-row plots, with six replications. The results are given in the table below.

Table - Effect of Seed Size on Yield, Number and Size of Tubers Produced keeping One Sprout to Each Seed Piece*

Seed Size	Yield in (g.)	No. of Tubers	Average Size of Tubers (g.)
10	259	6.56	39.5
20	265	6.80	39.0
40	260	6.64	39.3
S.E.	±11.34	±0.31	±2.30

* Average for each hill.

From the results presented above, it was evident that seed size had no significant effect on the total yield, total number of tubers, and individual size of the tubers produced. The data of the above experiment showed that the yield, total number of tubers produced by each seed tuber, and their individual size was governed by the number of sprouts produced rather than by the amount of food stored in them. Within the range of 10 to 40 g. the amount of stored food material had no influence upon yield and grade of produce.

The question of the optimum size of seed potatoes is one of much practical importance. Apart from the question of yields, that of cost per acre is pertinent. The question has been investigated by Salaman (150) in Great Britain. The results (shown overleaf) obtained by him indicated that normally the greatest net returns were obtained by the use of medium sized whole tubers, weighing 2 ounces, the size approximating to that obtained by passing through a 1½" - 1¾" riddle. In his experiment Salaman planted seed tubers at 12 inches apart in drills of 32 inches spacing.

Table - The Total Yields and the Net Returns of Crop as Influenced by Seed Sizes

Size of Seed (ozs.)	Total Crop in tons	Net Value of Crop £
4.0	11.8	22.85
2.66	11.8	34.95
2.0	11.5	38.95
1.6	11.0	38.9
1.33	10.7	38.65
1.0	10.6	41.37
0.8	10.0	39.93
0.57	9.07	37.0
0.35	8.3	35.7

In practice, however, it is impossible either to obtain or to use on a commercial scale seed approximating to 2 ounces in weight, or $1^{3}/_{4}$" in size. It is. therefore, desirable to know from within what limits of size, good results can be obtained. In order to obtain further information on this point Wallace (185) studied six different sizes of seed tubers in King Edward VII for four successive seasons, and got the following results.

Table - Average Returns of Ware Only and Ware and Seed Combined (Tubers planted at 16 inches apart)

Size of Seed Tuber	Av. Yield of Saleable Ware Over Four Years				Av. Returns of Ware only and Ware and Seed Combined					
					Ware Only			Ware and Seed Combined		
	T	C	q	lb.	£	s	d	£	s	d
$1\frac{1}{4}$" x 1"	7	7	1	18	36	16	0	41	8	10
$1\frac{1}{2}$" x $1\frac{1}{4}$"	7	16	0	11	39	0	0	44	2	4
$1\frac{3}{4}$" x $1\frac{1}{2}$"	8	7	2	22	41	18	0	47	13	7
2" x $1\frac{3}{4}$"	7	15	0	20	36	16	0	44	10	3
$2\frac{1}{4}$" x 2"	7	14	2	14	38	12	0	45	18	7
$2\frac{1}{2}$" x $2\frac{1}{4}$"	7	5	3	12	36	10	0	44	7	11

The highest return was obtained from seed dressed $1\frac{3}{4}$" - $1\frac{1}{2}$". The smallest size of seed showed up badly, but there was very little difference between any of the others. It should be mentioned here that these tests were done at one spacing only. It seems that a distance of 12-16 inches between the sets is commonly used by the growers in Great Britain.

Werner (189) studied tubers of varied size, 1 to 8 ounces per seed tuber and reported earlier plant growth from the larger seed tubers.

Since spacing and seed size are closely related with each other, they will be dealt with together in the following section.

(c) Effect of Seed Size and Spacing on the Yield of the Potato Crop

Findlay (69) reported that the factors of seed size and spacing are of importance in the economy of potato growing; a slight variation in one or both, apart from influencing the yield, affects considerably the initial outlay necessary for planting a required area. The size of seed and the spacing distance obviously influence the amount of seed needed to plant an acre. This is shown in the table below, which has been drawn up for 29 inches rows.

Table - Weight of Seed to Plant an Acre (Cwt)

Seed Size	Spacing Distances (in.)			
	12	15	18	21
Small, $1^1/_4$ to $1^3/_8$ in.	10	8	$6^3/_4$	$5^3/_4$
Medium, $1^3/_8$ to $1^5/_8$ in	15	12	10	$8^1/_2$
Large, $1^5/_8$ to 2 in.	$25^1/_4$	20	$16^3/_4$	$14^1/_2$

The seed requirement per acre, therefore must be taken into account when practical application of the results of the trials is considered.

Seed rates are determined by three factors - row spacing, sett spacing and the average weight of the seed. According to a report (6) on the survey of main crop potatoes in 1958 nearly 70 per cent of the acreage was planted in rows 28 inches apart, but 26 inch row spacing was common in the West Midlands and in South England. Actual sett spacings may vary appreciably within fields but, according to farmers' intentions, the greater part of the crop was planted at sett spacings between 12 and 16 inches, except in Scotland, where crops grown for seed were planted much closer. On the basis of farmers' stated seed rates in cwt. per acre, and the spacings which they aimed at, average sett weights were calculated for each region (table overleaf). The average weight of a seed potato was about 2 ounces, and the table confirms the findings of earlier surveys that certified seed is 10-15 per cent heavier than once grown seed. The difference in weight is due to the fact that in Scotland a $1^1/_4$" - $2^1/_4$" riddle size is used, whereas the English grower who is primarily a ware producer, keeps a smaller grade of seed from the once grown.

Table - Average Seed Rates, Sett Spacings and Estimated Sett Weights (Survey of 1958 by Potato Marketing Board)

	Average Seed Rate Cwt. per acre		Average Sett Spacing (Inches)		Average Sett Weight (oz.)	
	Certified	Other	Certified	Other	Certified	Other
East Anglia, Peat and Silt	20(22)*	18 (19)	15	13	2.3	1.9
Other	18	17	15	14	2.2	2.0
East Midlands, Yorks. and Lancs.	19 (19)	18 (17)	14	14	2.2	1.9
West Midlands.	13	15	17	16	1.7	1.9
S. England	19 (19)	18 (17)	15	14	2.2	1.9
N. England	22 (19)	18 (17)	14	15	2.4	2.2
Scotland Ware	24	18	12	13	2.2	1.9
Scotland Seed	30	18	9	12	2.2	1.7
Great Britain	21	17	14	14	2.3	1.9

* Figures in brackets are corresponding estimates for 1950.

Some of the investigations on the effects of seed size and spacing on the yield of crops are discussed overleaf.

Thomas (172) in an experiment with seed size versus spacing reported the following data:

Table -

Grade	Spacing (in.)	Yield (Tons/ acre	Amount of Seed Planted (Tons/ acre	Yield per ton of Seed (Tons/ acre	Net Yield* (Tons/ acre
Super, over $2^1/_4$ in.	13½	12.0	3.33	3.6	8.67
Medium, 1½-$1^7/_8$ in	13½	8.33	1.00	8.33	7.33
Small, 1-1½ in.	8	11.0	0.85	13.0	10.15

* Net yield equals total yield minus weight of seed planted.

The spacing of 13½ inches in the above table was too great for the medium seed, to give the maximum yield per acre. Thomas concluded that if the spacing had been 10 inches (above in the table) for the medium size seed, then the yield would have been in the region of 11 tons per acre. It can be seen that, provided small seed is planted closely, it may be expected in most seasons to yield as heavy a tonnage as large seed planted further apart. This is supported again by the work of Singh and Wakankar (157).

Bates (17) studied the effect of three seed sizes $1^1/_4$ x $1^3/_8$ inch, $1^3/_8$ x $1^5/_8$ inch, $1^5/_8$ x 2 inch at four spacings 12, 15, 18, 21 inch on the produce of crop and came to the following conclusions:

(1) Spacing influences yield in that, beyond certain limits, the decrease in yield is proportionate to the increase in distance between the setts.

(2) The limit to distance between the setts beyond which yield will fall varies with size.

(3) Seed size influences yield, larger seed giving higher yields than small seed with the same spacing.

(4) Size of seed influences the size of tubers produced. Small seed gives larger individual tubers than large seed with the same spacing.

Boyd (23) investigating the relationship between seed size and spacing suggested the use of an optimum seed rate. Provided the optimum seed rate (15-17 cwt. per acre for ware production and higher than this for seed production) was attained, the precise combination of seed size and spacing distance appeared to be of minor importance; that is, a grower should aim to plant at the optimum seed rate regardless of seed size. There is, however, an upper limit of spacing between setts which should not be exceeded however large the seed may be.

From the results mentioned above one may conclude that the actual spacing that is adopted must vary, as stated by Whitehead, McIntosh and Findlay (193) according to the size of tubers required, the variety, and the size of the seed. In seed production, where a high yield of small tubers is required, the setts should be planted closely, whereas in ware production, a wider spacing should be adopted. In varieties like Majestic which tend to produce large tubers, the seed should be planted more closely than Arran Pilot, which produce more numerous and smaller tubers. Similarly, the larger the size of the seed, the wider apart it must be planted. Bushnell (38) advocated wider planting of the setts as the number of plants or stems per hill increased.

For ware production Tinley and Bryant (174), using Great Scot and King Edward in rows 27 inches apart, have indicated that to obtain the most profitable return, chats (1" x $1^1/_4$") should be planted 12 inches apart while the larger seed (Great Scot 2" x $2^1/_2$", King Edward $1^3/_4$" x $2^1/_4$ ") may be planted 21 inches apart. Findlay and Sykes (69) suggested that the limit to spacing beyond which yield falls may vary with the size of seed and found that while the total yield declined when seed was planted more than 12 inches apart in 29 inch rows, the yield of ware was not significantly affected.

SECTION I

STORAGE PERIOD

1959-60

EXPERIMENTAL

SECTION I

STORAGE PERIOD

EXPERIMENTAL METHODS AND MATERIALS

Two experiments were carried out:

(i) Experiment 1 - To study the effects of various methods of storing and sprouting seed tubers on the subsequent yield of ware and seed.

(ii) Experiment 2 - To study the effects of varying periods of exposure to TCNB (Fusarex) on sprout and subsequent development.

The varieties used were Arran Pilot, an early variety, and Majestic, an early maincrop variety. Certified seed of both varieties were used. Seed tubers were graded by hand and they were of standard size (90 - 100 g. per set) for seed. Mis-shapen and damaged tubers were discarded.

The seed was placed in sprouting trays (24" x 12" x 3") for part of Experiment 1, and in metal bins (capacity approximately 2 cwt) for Experiment 2. A part of the seed for Experiment 1 was kept at low temperature storage (40° F), from where it was shifted periodically to different environments according to the treatments shown below, while part of the seed tubers were stored in a pit in the open field. It should be pointed out here that the tubers stored in pit were 14.5 per cent heavier than those stored at low temperature. A thick layer of straw (about 12") covered the clamp of potatoes and about 6" of soil was used to cover the straw. Half the quantity of the seed for Experiment 2 was treated with TCNB at the rate of 10 lb. per ton of seed tubers, while the rest was left untreated. The seed in the bins was stored in a poorly lit barn at Boghall Farm which was frost proof.

A sample of 10 seed tubers of each treatment was studied for sprouting behaviour during the storage period in each experiment.

TREATMENTS

Experiment 1

1. Storage at 40°F all through storage period.
2. Storage at 40°F all through except 10 days at 65 - 70°F in the middle of November.
3. Storage at 40°F all through except 10 days at 65 - 70°F in the middle of January.
4. Storage at 40°F all through except 10 days at 65 - 70°F in the middle of November and January.
5. Storage at 40°F till 20th. February; sprouted in trays in glasshouse in the light.
6. Storage at 40°F till 20th. February (except 10 days at 65 - 70°F in the middle of November); sprouted in the light.
7. Storage at 40°F till 20th. February (except 10 days at 65 - 70°F in the middle of January); sprouted in the light.

8. Sprouted October to April in glasshouse in the light.

9. Sprouted October to April in glasshouse in the dark.

10. Sprouted in the dark; desprouted before planting.

11. Sprouted in the dark; desprouted twice, 20th. February and 14th. March; sprouted in the light.

12. Storage in pit; planted.

13. Storage in pit; desprouted before planting.

14. Storage in pit till 20th. February (Arran Pilot desprouted); sprouted in the light.

Experiment 2

1. Storage without TCNB October - April; Arran Pilot desprouted before planting.

2. Storage with TCNB October - April.

3. Storage without TCNB October - 23rd. December; Arran Pilot desprouted; sprouted in the light.

4. Storage with TCNB October - 23rd. December; sprouted in the light.

5. Storage without TCNB October - 20th. February; Arran Pilot desprouted; sprouted in the light.

6. Storage with TCNB October - 20th. February; sprouted in the light.

7. Storage without TCNB October - 23rd. March; Arran Pilot desprouted; sprouted in the light.

8. Storage with TCNB October - 23rd. March; sprouted in the light.

The Environmental Conditions During the Storage Period

The temperature (maximum and minimum) was recorded periodically and the data is given in Table 1. The temperature in the glasshouse was controlled by a thermostat, and from December to the middle of March, the minimum temperature ranged from 44° - 55°F, while the maximum temperature ranged from 56° - 66°F. From the middle of March onward the minimum temperature recorded was 51°F, whereas the maximum temperature rose to 78°F.

The farm at Boghall was cool all the time, and the minimum temperature during the storage period was 32°F in the middle of February, while the maximum temperature was 54°F in the early part of November and 52°F in the later part of the storage period, i.e. at the end of April.

Temperatures were not recorded inside the clamp of potatoes, which was sited in an open field.

Disease

During the month of March the sprouts of the tubers chitted in the glasshouse were infected with aphis (greenfly). The attack of aphis was more virulent in the month of April, when warm weather favoured their breeding. Seed tubers chitted for a longer period in the light or in the dark seemed to be more affected than those chitted for a shorter period. The after-effect of this infestation was the outbreak of the disease of leaf-roll. The influence of this on the growth of plants will be discussed in Section II.

TABLE 1.

Storage Temperature Record, 1959-60

Glasshouse Temperature Record F°			Boghall Barn Temperature Record F°		
Date	Minimum	Maximum	Date	Minimum	Maximum
23.12.1959	55	62	9.11.1959	42	54
28.12.1959	53	58	17.11.1959	39	42
31.12.1959	51	58	23.11.1959	39	45
6.1.1960	50	60	6.1.1960	39	45
13.1.1960	52	56	19.1.1960	36	42
18.1.1960	48	56	25.1.1960	34	45
2.2.1960	47	66	9.2.1960	36	47
10.2.1960	50	60	17.2.1960	32	35
16.2.1960	44	62	22.2.1960	32	35
22.2.1960	49	54	7. 3.1960	37	42
8.3.1960	52	56	16.3.1960	38	46
18.3.1960	52	63	21.3.1960	39	44
22.3.1960	48	70	29.3.1960	39	47
15.4.1960	48	78	2.4.1960	39	45
21.4.1960	51	68	14.4.1960	42	52
26.4.1960	51	70	26.4.1960	43	54

EXPERIMENTAL RESULTS

Experiment 1

(i) Effect of Low Temperature Storage, Heat Treatment and Chitting on the Development of Sprouts

(a) Low Temperature and Heat Treatment

Table 2 shows that storage of seed tubers continuously at 40°F kept them dormant for a long time, and no visible sprouts were noticed till November in Arran Pilot, and January in Majestic. A short period of high temperature in November brought the seed tubers to visible sprouting by the end of November for Arran Pilot, and the end of December for Majestic. Apparently heat treatment either once or twice did not result in much difference in the number of sprouts per seed tuber in Arran Pilot, while there was a considerable difference in the variety Majestic.

TABLE 2

Experiment 1, 1959-60

Distribution of Sprouts[1] per Seed Tuber of Various Size (cm) Group and Average Length[1] (cm) of the Longest Sprout per Seed Tuber on 22.4.1960 as Influenced by Low Temperature Storage and Heat Treatment.

Treatment Applied to Tubers Stored at 40° F During Winter	Arran Pilot								Majestic							
	+	0-1	1-3	3-5	5-10	10-	No. Sprouts per Seed Tuber	Average Length of the Longest Sprout	+	0-1	1-3	3-5	5-10	10-	No. Sprouts per Seed Tuber	Average Length of the Longest Sprout
1. No heat treatment	1.7	16.1	0.1	-	-	-	17.9	0.7	6.1	2.8	-	-	-	-	8.9	0.1
2. Heat treatment in November	2.0	12.6	2.0	0.5	-	-	17.1	3.3	4.5	7.6	-	-	-	-	12.1	0.2
3. Heat treatment in January	0.6	15.1	1.7	-	-	-	17.4	2.2	4.7	13.8	-	-	-	-	18.5	0.2
4. Heat treatment in November and January	1.4	13.6	3.2	0.6	0.1	-	18.9	3.7	2.6	14.4	-	-	-	-	17.0	0.6

1. Average of 10 Seed Tubers
+ Visible Sprouts.

A part of the difference in Majestic between 40°F and the heat treatment, could be due to the fact that the sprouts had not developed at 40°F. There was an increase in the number of sprouts and average length of the longest sprout per seed tuber as a result of increasing the amount of heat the tubers were subjected to. The double heat treatment resulted in longer sprouts in both varieties than a single one.

Effect of Chitting

Three lots of tubers were taken from the first three treatment lots (Table 2) i.e. one lot from tubers held all through at 40°F, the second lot from tubers subjected to heat in November and the third lot from tubers subjected to heat in January respectively; and chitted in the glasshouse from 20th. February onwards. The sprout-growth was recorded as before and the data is given in Table 3.

TABLE 3

Experiment 1, 1959-60

Distribution of Sprouts[1] per Seed Tuber of Various Size (cm) Group and Average Length[1] (cm) of the Longest Sprout per Seed Tuber on 22.4.1960 as Influenced by Chitting

Treatment Applied to Tubers Stored at 40° F During Winter	Arran Pilot								Majestic							
	+	0-1	1-3	3-5	5-10	10-	No. Sprouts per Seed Tuber	Average Length of the Longest Sprout	+	0-1	1-3	3-5	5-10	10-	No. Sprouts per Seed Tuber	Average Length of the Longest Sprout
5. Chitted February-April	-	11.7	1.4	1.4	1.7	0.1	16.3	6.5	0.8	10.3	2.5		-	-	13.6	1.9
6. Heat Treatment in November and chitted February-April	-	10.1	1.5	2.3	0.3	-	14.2	4.4		11.8	2.5		-	-	14.3	2.4
7. Heat Treatment in January and chitted February	-	7.7	3.4	0.8	2.0	-	13.9	7.5	0.7	14.1	2.5		-	-	17.3	2.2
8. Chitted October - April	-	2.3	0.2	0.1	0.4	0.6	3.6	11.5	1.4	10.1	0.9	0.6		-	13.0	3.4

1 Average of 10 Seed Tubers.

The two varieties seemed to respond differently. Heat treatment in November or January followed by chitting reduced the average number of sprouts per seed tuber in Arran Pilot while it increased it in Majestic. The reason we notice a successive reduction in the number of sprouts per seed tuber in Arran Pilot is that early sprouted (November or January heat treatment) seed tubers, some of the sprouts began to dry off in the later part of April and became detached from the mother tuber. Majestic, on the other hand, developed more sprouts under the same conditions. The average length of the longest sprout was not much influenced by the heat treatment in November or January.

Seed tubers sprouted from October to April produced 3.6 and 13.0 sprouts per seed tuber in Arran Pilot and Majestic respectively. But the table shows that for sprouts of 1.0 cm. and over there was only 1.3 in Arran Pilot, and 1.5 in Majestic. It will be seen later in Section II that only sprouts over 1.0 cm. (i.e. in this case from the apical region) develop into main stems, while others remain suppressed under the influence of apical dominance.

(ii) Effect of Storage in the Dark on Sprout Development

Seed tubers stored in the dark in the glasshouse from October to April almost always produced one long dominant sprout (in some tubers, two) which mostly developed from the apical region. It measured 80-120 cm. in Arran Pilot and 40-50 cm. in Majestic at the time of planting. Other sprouts were below

1.0 cm. and were drying off. This sprouting resulted in severe shrivelling of the mother tuber, which felt rubbery.

One lot under similar storage conditions was desprouted twice, on 20th. February and 14th. March. Desprouting in February resulted in a loss of weight of 14.0 g. and 2.5 g. (fresh weight) per 100 g. of seed tubers in Arran Pilot and Majestic, respectively, while the desprouting in March lost 2.2 g. and 0.4 g. (fresh weight) per 100g. of seedtubers in Arran Pilot and Majestic respectively.

Another lot stored under similar conditions, when desprouted only once, i.e. before planting, resulted in a loss of 87.9 g. and 11.5 g. per 100 g. of seed tubers for Arran Pilot and Majestic respectively.

In each case Arran Pilot shrivelled more than Majestic. The number of sprouts per seed tuber, and the average length of the longest sprout are shown in Table 4.

TABLE 4

Experiment 1, 1959-60

Distribution of Sprouts[1] per Seed Tuber of Various Size (cm) Group and Average Length[1] of the Longest Sprout per Seed Tuber on 22.4.1960 as Influenced by Desprouting

Treatment Applied to Tubers Stored in the Dark	Arran Pilot								Majestic							
	+	0-1	1-3	3-5	5-10	10-	No. Sprouts per Seed Tuber	Average Length of the Longest Sprout	+	0-1	1-3	3-5	5-10	10-	No. Sprouts per Seed Tuber	Average Length of the Longest Sprout
9. No de-sprouting	-	6.0	0.4	-	0.1	1.6	8.1	94.2	4.4	7.3	0.3	0.2	0.2	1.3	13.7	39.4
10. De-sprouted once before planting	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11. De-sprouted twice, 20th. February and 14th. March.	-	12.6	4.3	-	-	-	16.9	2.3	-	12.5	1.5	-	-	-	14.0	1.6

1. Average of 10 Seed Tubers

Desprouting twice doubled the number of sprouts per seed tuber in Arran Pilot, while there was a small increase in Majestic.

Since a large amount of stored food material was lost through the first desprouting in both varieties, the sprout growth after the second desprouting was very slow - so slow in Arran Pilot that by planting time, short spindly sprouts developed, which were weak.

(iii) Effect of Storage in Pit on Sprout Development

A sample of seed tubers was taken out from the pit on 20th. February and sprouted till planting in the glasshouse as before. Long slender etiolated sprouts had developed in Arran Pilot and these were removed before chitting. A loss of 0.3 g. per 100 g. of seed tubers was recorded due to etiolated sprout-growth in the pit. Only 2-5 mm sprout-growth had occurred in Majestic. Both the varieties exhibited multiple sprouting at the time of sampling.

Two other samples were taken from the same pit on 24th. April, five days before planting. Etiolated sprouts of up to 6-10 cm. were noted in Arran Pilot while they were only 0.5 - 1.0 cm. long in Majestic. One of these samples was desprouted and a loss of 3.6 g. per 100 g. of seed tubers was noted in Arran Pilot. These sprouts appeared brittle and their attachment to the mother tubers was not very firm. In the whole lot of Majestic tubers, only a few sprouts, 0.5 - 1.0 cm. long, were removed. Table 5 gives the average number of sprouts, and the average length of the longest sprout per seed tuber.

TABLE 5

Experiment 1, 1959-60

Distribution of Sprouts[1] per Seed Tuber of Various Size (cm) Group and Average Length[1] of the Longest Sprout per Seed Tuber on 22.4.1960 as Influenced by Pit Storage, Desprouting and Chitting

Treatment applied to Tubers Stored in Pit during the Winter	Arran Pilot								Majestic							
	+	0-1	1-3	3-5	5-10	10-	No. Sprouts per Seed Tuber	Average Length of the Longest Sprout	+	0-1	1-3	3-5	5-10	10-	No. Sprouts per Seed Tuber	Average Length of the Longest Sprout
12. No Desprouting before planting.	0.4	6.5	1.2	1.0	2.3	0.9	12.3	11.2	3.7	13.7	-	-	-	-	17.4	0.6
13. Desprouted before planting	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14. Chitted from February after desprouting Arran Pilot	-	9.0	5.0	-	-	-	14.0	2.5	1.2	13.0	2.4	-	-	-	16.6	1.6

1 Average of 10 seed Tubers.

In Arran Pilot, more sprouts were developed in those chitted in February, than in the undesprouted seed tubers, whereas there was little difference in Majestic.

Arran Pilot produced long etiolated sprouts in the pit before planting while Majestic developed a short sprout.

x x x

The nature of sprouting due to five varied types of treatments being (i) storage of seed tubers at $40^{o}F$ for the whole period (Tr.1); (ii) storage of seed tubers at $40^{o}F$ until February and then sprouted until planting (Tr. 5: multiple sprouting phase); (iii) sprouting seed tubers all the time in the light in glasshouse (Tr. 8: apical dominance phase); (iv) sprouting seed tubers all the time in the dark in glasshouse (Tr. 9: apical dominance phase); and (v) desprouting seed tubers twice (20th. February and 14th. March) after sprouting in the dark and subsequent chitting (Tr. 11: apical dominance broken) is shown in Figure A_1 for Arran Pilot and in Figure A_2 for Majestic respectively.

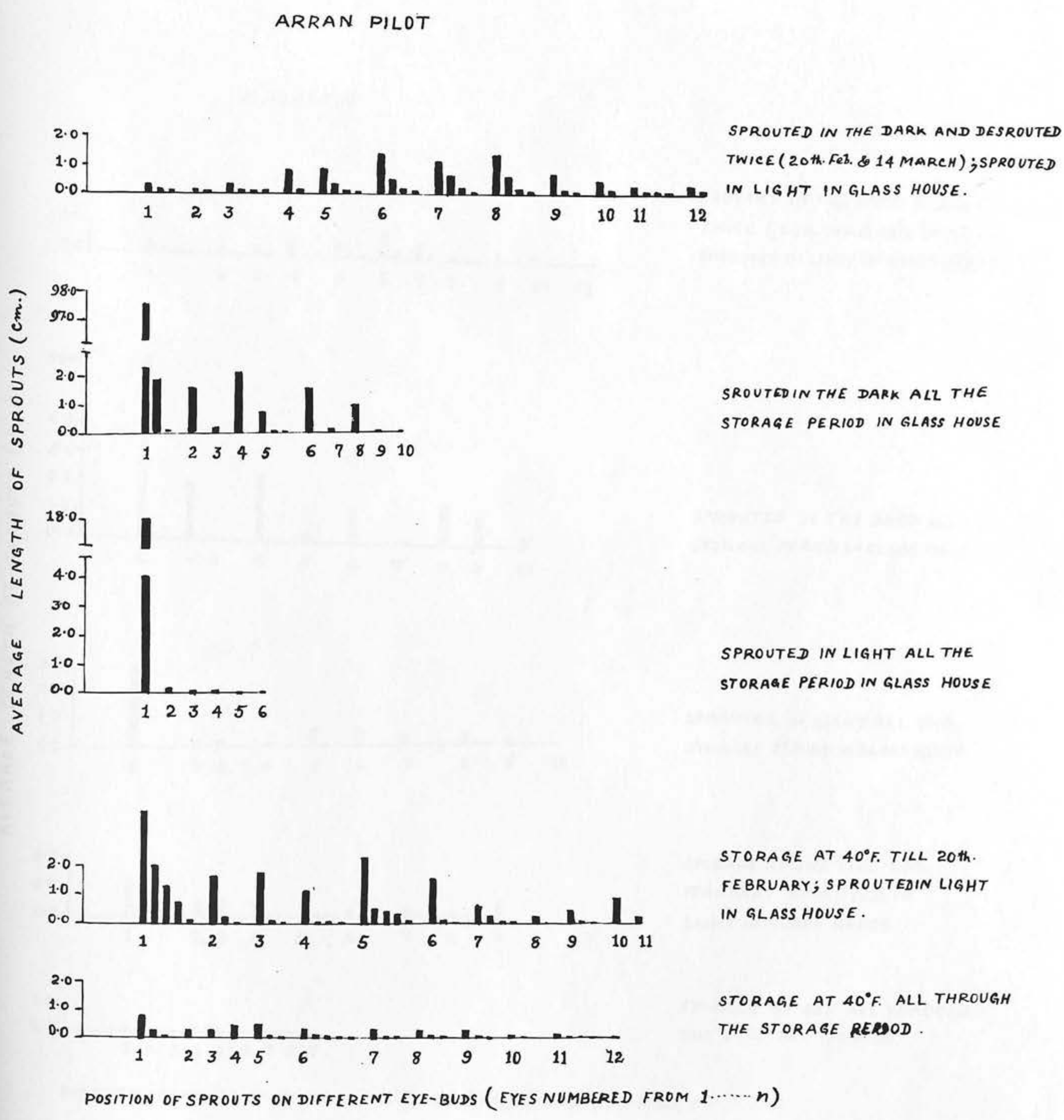
The figures show that sprouting from February until planting (Tr. 5) and desprouting (Tr. 11) both remove the apical dominance by developing more eye buds to sprouts on the middle and heel region of the seed tubers. The desprouting also reduced the average length of sprouts on the apical region and slightly increased it on the middle regions showing a complete disappearance of apical dominance.

The tubers after treatments and before planting are shown in Plates, I and II (p. 86C and 86D). Also the nature of plant development (plants lifted on 8th. June, 1960 i.e. 40 days after planting) due to those treatments is shown in Plates, III to VI in Section II (p. 133A, 133B, 133C and 133D). It should be noted here that plants from seed tubers chitted all the time gave an earlier plant-growth and tuberization than those of other treatments.

EXPERIMENT 1, 1959-60

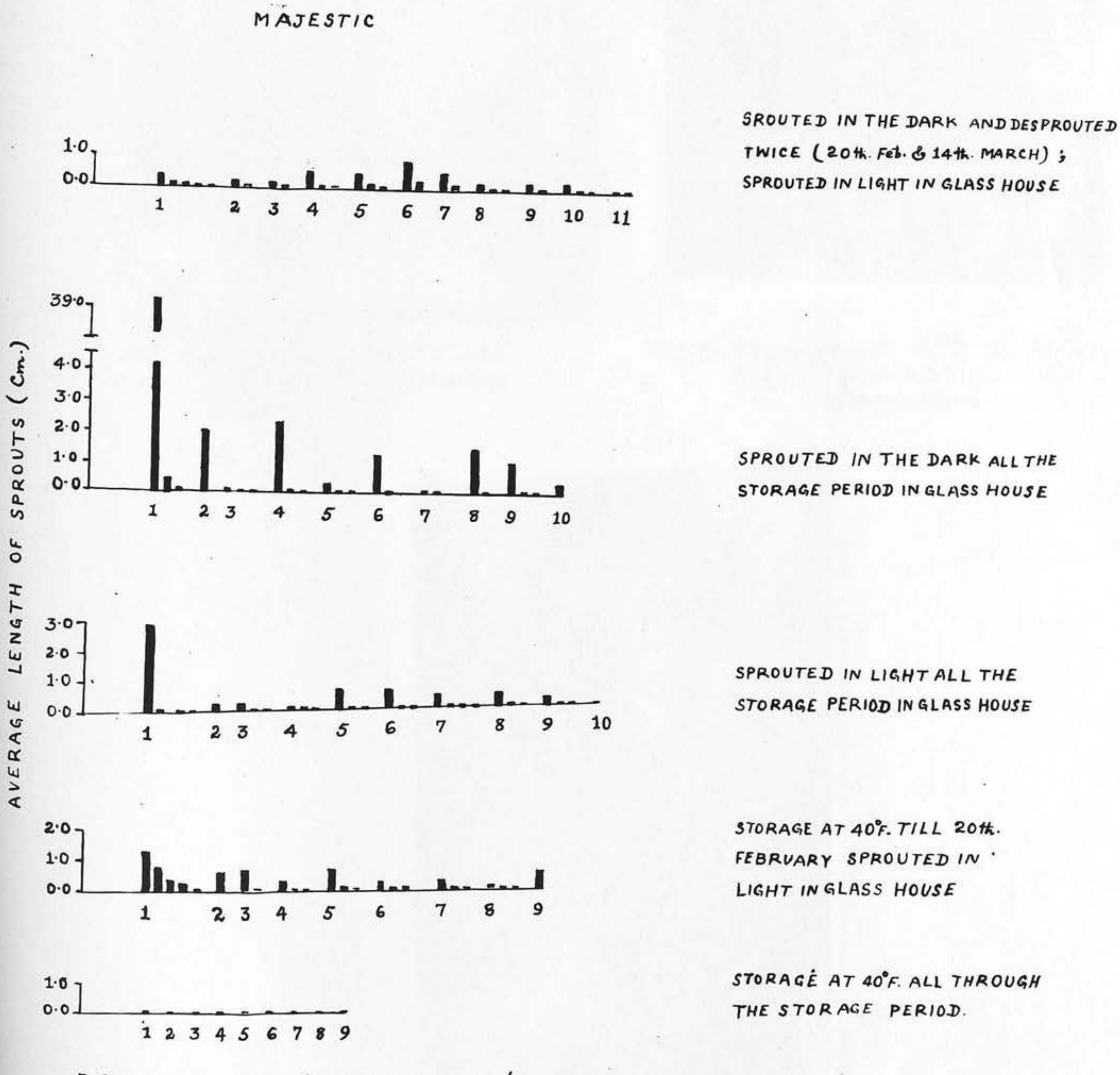
Fig. A_1 NUMBER OF SPROUTS FROM DIFFERENT EYES OF SEED TUBERS AS RECORDED FROM THE APICAL END TO THE HEEL REGION IN SUCCESSIVE ORDER ON 22-4-1960

(AVERAGE OF 12 SEED TUBERS.)



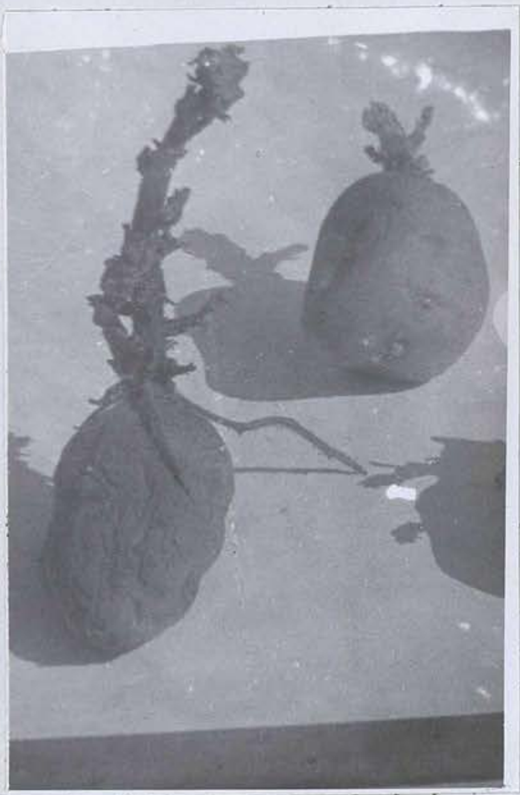
EXPERIMENT 1, 1959-60

Fig. A_2 NUMBER OF SPROUTS FROM DIFFERENT EYES OF SEED TUBERS AS RECORDED FROM THE APICAL END TO THE HEEL REGION IN SUCCESSIVE ORDER ON 22-4-1960

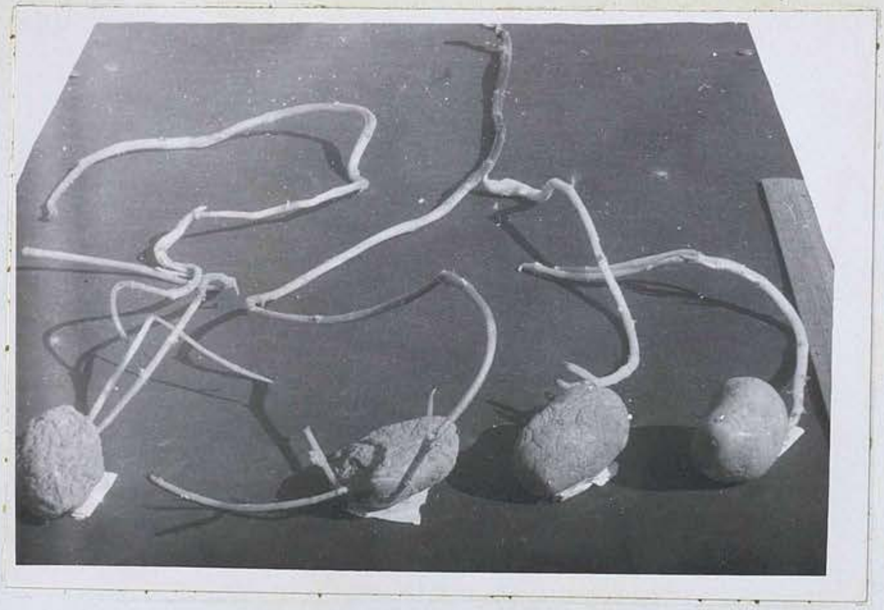


Tr.1. Storage at $40^{\circ}F$ all through the storage period.

Tr.5. Storage at $40^{\circ}F$ till 20th. Feb.; sprouted in light in glasshouse.



Tr.8. Sprouted in light all the storage period in glasshouse.



Tr.9. Sprouted in the dark all the storage period in glasshouse.

Tr.11. Sprouted in the dark and desprouted twice(20th.Feb. and 14th. March); sprouted in light.

Experiment 2

A sample of tubers was taken from the two lots (treated and untreated) in the bins at varying times as follows, 23rd. December, 20th. February, 23rd. March for chitting in the glass-house. Tubers were also left in the bins till date of planting.

TCNB treatment resulted in an increase in the number of sprouts per seed tuber at all dates of chitting, the increase is more apparent in Arran Pilot than Majestic, as shown in Table 6. Treatment with TCNB for the whole storage period did not show much difference from untreated tubers in the number of sprouts in either variety. A slight reduction in the number of sprouts was noted in Majestic as this variety sprouted late and all the sprouts probably had not developed at time recording took place.

TABLE 6

Experiment 2, 1959-60

Distribution of Sprouts[1] per Seed Tuber of Various Size (cm) Group and Average Length[1] of the Longest Sprout per Seed Tuber on 15.4.1960.

Arran Pilot

Dates of Chitting	No TCNB +	0-1	1-3	3-5	5-10	10-	No. Sprouts per Seed Tuber	Average Length of the Longest Sprout	TCNB +	0-1	1-3	3-5	5-10	10-	No. Sprouts per Seed Tuber	Average Length of the Longest Sprout
December	0.3	4.0	0.4	0.1	0.8	0.9	6.5	12.4	0.4	7.6	0.9	0.4	0.7	0.8	10.8	12.0
February	-	7.0	1.9	2.4	0.6	-	11.9	5.1	0.1	15.4	2.4	1.8	0.5	-	20.2	4.9
March	-	12.2	3.9	-	-	-	16.1	1.9	16.7	4.2	-	-	-	-	20.9	1.5
No chitting	-	5.1	2.3	2.0	0.7	0.2	10.3	6.7	-	6.6	4.3	-	-	-	10.9	0.1

Majestic

Dates of Chitting	No TCNB +	0-1	1-3	3-5	5-10	10-	No. Sprouts per Seed Tuber	Average Length of the Longest Sprout	TCNB +	0-1	1-3	3-5	5-10	10-	No. Sprouts per Seed Tuber	Average Length of the Longest Sprout
December	1.7	7.0	0.7	0.5	-	-	9.9	3.1	1.9	8.7	1.0	0.4	-	-	12.0	3.1
February	0.8	11.4	3.2	0.2	-	-	15.6	2.5	0.6	13.1	2.4	-	-	-	16.1	2.0
March	1.6	12.2	-	-	-	-	13.8	0.8	1.9	15.5	-	-	-	-	17.4	0.8
No chitting	3.7	7.7	-	-	-	-	11.4	0.2	2.2	7.8	-	-	-	-	10.0	0.1

1 Average of 10 Seed Tubers.

Untreated seed tubers of Arran Pilot developed long etiolated sprouts in February which were removed before chitting in February and March. Sprouts as big as 4-7 cm. and 8-12 cm. were recorded in February and March in Arran Pilot, which resulted in a loss of 0.5 g. and 0.8 g. per 100 g. of seed tubers respectively. When a sample of seed tubers was taken from the same lot in April, before planting, sprouts as big as 10-16 cm. per seed tuber were noted, which resulted in a loss of 1.3 g. per 100 g. of seed tubers. These sprouts were thin, slender and brittle. The removal of such sprouts before chitting might increase the number of subsequent sprouts. The seed tubers were firm and healthy.

TCNB application showed an after-effect on the sprout growth at all date of chitting. Treated seed tubers always tended to produce shorter sprouts than untreated ones in both varieties at all dates of chitting.

Seed tubers chitted from December to April clearly demonstrated the existence of apical dominance in both varieties. As a result one dominant sprout, which was vigorous in growth, developed on the apical end of the seed tuber. Other sprouts, which were smaller than 1.0 cm, became detached from the mother tuber at the later part (March-April) of the chitting period. The apically dominant sprout developed as many as 15-20 nodes in Arran Pilot and 5-8 nodes in Majestic. The lower nodes developed stolons, 4-5 cm. long.

Chitting from February or March caused multiple sprouting. The temperature inside the glasshouse rose above 70°F in the later part of the storage period. Sprouts of Arran Pilot grew much faster than Majestic and became too long. The sprouts produced by Arran Pilot tubers were 4.9 - 5.1 cm. long when chitted in February and 1.5 - 1.9 cm. when chitted in March and the respective figuresfor Majestic potatoeswere 2.0 - 2.5 cm. and 0.4 - 0.8 cm. Usually 3 or 4 sprouts (sometimes even 5 sprouts) per eye-bud were noted, but here also, the apical dominance was present since the central sprout of each eye was longer than the side ones. The internodes of sprouts developed from seed tubers chitted in February were shorter than the ones chitted in March, and as many as 6-10 nodes and 3-4 nodes per dominant sprout were recorded in Arran Pilot for chitting from February and March respectively, while for the same period they were 3-4 and 2-3 nodes per dominant sprout in Majestic. In all the instances sprouts of Majestic developed shorter inter-nodes than those of Arran Pilot.

SECTION II

EFFECT OF STORAGE ON THE SUBSEQUENT DEVELOPMENT OF THE PLANT IN THE FIELD

1959-60

SECTION II

EFFECT OF STORAGE ON THE SUBSEQUENT DEVELOPMENT OF THE PLANT IN THE FIELD

1960

Experimental Methods and Materials

The main experiments (and the sub-experiments) were conducted on the same area of land on Boghall Farm about six miles south-west of Edinburgh. The description of the soil is given below:

Texture:	Sandy clay loam.
Drainage:	Imperfect.
Sub-soil:	Sandy clay loam of boulder clay derived from mixed materials mainly carboniferous in origin.
pH:	6.1 - 6.2
Available potassium:	Moderate.
Available phosphate:	Moderate.

The previous crop was grass (1955-59), cut fairly frequently. The area was cultivated and harrowed in the beginning of April. Ridges were drawn at 27" with a 3-row potato ridger which also applied the fertilizer (10-10-18) at the rate of 7 cwt. per acre. A portion of the field was divided into four plots to accommodate two main experiments (experiment 1 and experiment 2) and corresponding to the two experiments, two sub-experiments (No. 1 and 2) for detailed growth studies. Planting was carried out on the 29th. and 30th. April in sunny weather.

The Main Experiments, 1959-60

The two main experiments comprised the following factors:

(a) Varieties

(i) Arran Pilot (an early variety)

(ii) Majestic (an early main crop variety)

(b) Spacing

(i) 9"

(ii) 18"

(c) Treatments

(i) 14 treatments, already described in Section I for Experiment 1.

(ii) 8 treatments already described in Section I for Experiment 2.

The Layout:

The main experiments were of split plot in randomized block design. The field was divided into two equal parts to include two replications in each of the experiments. Each replication was then divided into four equal parts to accommodate two main factors (2 x 2) which were allocated at random. Each main plot was further split into fourteen sub-plots for experiment 1, and eight for experiment 2, the treatments again being allocated at random. The total number of plots was 112 (2x2x2x14) for experiment 1 and 64 (2x2x2x8) for experiment 2. Two discard drills were used in each of the experiments along the drills to separate the main plots of variety and spacing, but no discard tubers were planted within the drill. Each plot consisted of two drills of 15 feet long. The area of each plot was $\frac{1}{588}$ acre (4.5' x 15.0' = 67.5 sq. feet).

The Sub-Experiments, 1959-60

The sub-experiments comprised the following factors:

(a) Varieties:

(i) Arran Pilot

(ii) Majestic

(b) Treatments:

(i) 14 treatments, described before in Section I for Experiment 1.

(ii) 8 treatments, described before in Section I for Experiment 2.

The Layout:

There were four replications in each of the sub-experiments. It was of randomized block design. There were six samplings to be made fortnightly. In each replication the treatments of each experiment were allocated in such a way that plants of all the treatments could be lifted from a single block, the treatments again being randomized. Between each block there was a discard row so that sampling could be made without injuring the neighbouring plants in other blocks. The two varieties were planted in two separate blocks. The distance between the plants was 18 inches to allow treatment effects to be expressed.

Dates of Field Operation and Observations

1. Planting................29.4.60 and 30.4.60.

2. Harrowed Down Ridges...9.5.60 and 18.5.60.

3. Cultivation............1.6.60 and 15.6.60.

4. Ridging................15.6.60.

5. Sampling.

Sub-Experiment 1

First sampling	8.6.60.
Second sampling	23.6.60.
Third sampling	8.7.60.
Fourth sampling	23.7.60.
Fifth sampling	8.8.60.
Sixth sampling	23.8.60.

Sub-Experiment 2

First sampling	14.6.60.
Second sampling	30.6.60.
Third sampling	14.7.60.
Fourth sampling	28.7.60.
Fifth sampling	11.8.60.
Sixth sampling	29.8.60.

6. Harvesting................ 8.10.60 and 10.10.60.

7. Grading................... 17.10.60.

PLANT GROWTH STUDIES

Plant growth studies were made to determine the reaction of the plants more fully.

Sampling of the Sub-experiments

One block from each replication was chosen at random for sampling. The plants were lifted out by fork carefully without injuring the roots and tubers, and kept inside a polethene bag to ensure that the plants maintained turgidity for a reasonable period. The plants were immediately brought to the laboratory for washing. Care was taken that the main-stems did not become detached from the mother tuber.

Dry Matter Determination and Measurement of Plant-parts.

After washing, the plants were laid in plastic trays overnight for moisture to dry off. The foliage part was cut-off and the length of the above-ground was measured. The tubers were graded into different sizes (not shown in the table). The foliage and tubers were cut into pieces and dried in an electric oven at 100°C overnight to determine the dry weight (4-6 hours was enough to dry off foliage, and 10-15 hours to dry off tubers, sliced 0.5 cm. thick).

Data Collected from the Main Experiments

The following records were made from the main experiments:

1. Plant emergence and flowering were recorded twice a week during the periods concerned.

2. The total yield, and the yield of different grades of potato tubers, viz. ware (over 2¼" mesh riddle), seed (1¼" x 2¼"), and chats (through 1¼" mesh riddle) were recorded for each plot.

Data Collected from the Sub-Experiments

1. The number of above-ground[3] stems (main-stems[1] + underground branches[2]).
2. Positions from which the main-stems developed on the mother seed tuber (i.e. apical, middle and heel region).
3. Number of nodes.
4. The length of the above-ground stem.
5. The number and length of stolons developing from underground stems in the first sampling.
6. Number of tubers of different sizes.
7. Dry matter weight of green foliage (underground stem excluded) and tubers.

Due to an unequal number of plants being studied, and also because of bulking the foliage and tuber sets of all the replications together for drying, the results of the sub-experiments were not capable of being statistically analysed.

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[1] Main stem: The stem which developed from a sprout.

[2] Underground branch: Secondary stem arising from an underground node of a main stem.

[3] Above ground stem: All stems showing above ground, i.e. includes both main stems and branches from main stem arising from below soil surface.

Disease

Plants from seed tubers which were chitted in the glass-house, and were severely attacked by aphis (greenfly), showed "leaf-roll" infection about 50 days after planting. All the plants from tubers which were stored in the glasshouse were immediately discarded from the main experiment, in order to save the plants of other treatments. Only the infected plants or the plants which showed the first symptoms of leaf-roll were rogued out from the sub-experiments in order to study the effect of treatments on as many plants as possible. Late Blight (phytophthora infestans) appeared late in 1960, towards the end of August, after the tubers had attained maximum bulking.

Harvesting

The net area per plot of the main experiments harvested was 2 drills, 15 feet long, leaving one discard outside the extreme end of the drill. After one week, when the soil sticking to the tubers was dry, grading was carried out. The number and weight of each grade was noted separately for each individual plot. Produce of each plot was riddled separately into the following categories:

(i) ware - above $2^1/_4$" mesh riddle.

(ii) seed - between $1^1/_4$" and $2^1/_4$" mesh riddle.

(iii) chats - below $1^1/_4$" mesh riddle.

Weather Features

The weather was not unusual in any respect. Throughout the growing season there was never any scarcity of water. The sunshine was normal. There was no frost damage. The meteorological data for the year 1960 is given in Table 7.

TABLE 7

Weather Report, 1960

Months	Temperature (F^{o}) Minimum	Temperature (F^{o}) Maximum	Rainfall (inches)	Average Sunshine per day
January	32.0	40.9	3.22	1.18
February	34.2	34.8	2.71	3.36
March	40.0	50.4	1.58	2.59
April	39.0	54.0	1.17	4.1
May	42.2	61.5	1.17	4.3
June	48.8	65.2	1.25	6.0
July	48.5	62.9	3.17	3.35
August	47.5	58.0	4.25	3.46
September	45.7	59.1	1.60	3.78
October	43.4	52.2	2.98	1.22
November	34.6	46.1	3.29	1.78
December	31.0	40.5	4.17	1.01

Statistical Analysis and the Methods of the Presentation of Data

The data were subjected to the "analysis of variance" appropriate to the designs. For the rate of plant emergence, and yield data of the main experiment, there were two estimates of error applicable to: (a) The effects of variety, spacing and their interaction; (b) the effect of storage treatments and their interaction with variety and spacing.

Results significant at the 5 per cent level of significance are marked with one asterisk, and those significant at the 1 per cent level, with two asterisks.

PLANT GROWTH STUDIES

(a) Effect of Low Temperature and Heat Treatment - Experiment 1,1959-60

(i) Plant Emergence:

Counts of plants were made twice a week in Experiment I. Due to difficulty in locating the position of each plot in the field, the count of emergence was delayed and the first count was made 27 days after planting when some of the plots had already over 75 per cent emergence. In the second count, however, most of the plots had 100 per cent plant stand and it was difficult to distinguish the treatment response. The first count was considered and analysed statistically (see analysis of variance Table 101 in the appendix).

TABLE 8

Experiment 1, 1959-60

Number of Plants per Plot Emerged on 26.5.1960 (27 Days after Planting) as Influenced by Low Temperature and Heat Treatment During Storage at 40°F.

Treatment Applied to Tubers Stored at 40°F During Winter	Arran Pilot	Majestic	Mean
1. No Heat Treatment	14.0	0.2	7.1
2. Heat Treatment in November	23.9	1.2	12.5
3. Heat Treatment in January	24.3	4.5	14.4
4. Heat Treatment in November and January	23.0	10.0	16.5
S.E.	$\pm$ 2.5	$\pm$ 2.5	$\pm$ 1.8

Table 8 shows that continuous storage at 40°F. resulted in late emergence of plants. Heat treatment for 10 days at any period (November or January) increased the rate of emergence in both the varieties, the heat treatment of January being more effective than November. However, the double heat treatment further increased the rate of emergence in Majestic, but slightly reduced it in Arran Pilot. The conclusion is that plants from the seed treated with heat emerge quicker than those from seed tubers stored at 40°F all the time.

(ii) Weight of Dry Matter (g) in Foliage and Tuber Sets - Sub Experiment 1,1959-60.

The data from the growth study (sub-experiment 1) are shown in Table 9. It can be seen that storage of seed tubers at 40°F throughout the storage period resulted in a slow plant growth at an early stage of development. Tuberization was also delayed as a result. Heat treatment during November or January increased the dry matter yield of foliage and tuber sets at an early development stage. This increase was noticed in both the varieties. At later dates this increase of foliage dry matter and tuber sets was overtaken by the continuous cold storage treatment.

TABLE 9

Sub-Experiment 1, 1959-60

Dry Matter (g.) Changes at Different Stages of Plant-Growth. (Average of 4 Hills).

Weight of Foliage per Hill (g.)

Treatment Applied to Tubers Stored at 40°F During Winter	Arran Pilot						Majestic					
	June 8	June 23	July 8	July 23	Aug. 8	Aug. 23	June 8	June 23	July 8	July 23	Aug. 8	Aug. 23
1. No Heat Treatment	4	20	52	91	134	144	2	18	63	109	150	155
2. Heat Treatment in November	4	24	60	107	107	185	2	22	62	101	133	162
3. Heat Treatment in January	5	31	48	60	65	94	4	24	63	118	146	161
4. Heat Treatment in November and January	7	24	72	86	120	170	4	19	64	73	118	131

Weight of Tubers per Hill (g.)

Treatment Applied to Tubers Stored at 40°F During Winter	Arran Pilot						Majestic					
	June 8	June 23	July 8	July 23	Aug. 8	Aug. 23	June 8	June 23	July 8	July 23	Aug. 8	Aug. 23
1. No Heat Treatment	-	0.5	22	88	306	367	-	0.1	21	81	204	282
2. Heat Treatment in November	-	1.0	38	154	239	342	-	0.4	25	88	183	301
3. Heat Treatment in January	-	0.7	37	140	233	364	-	0.6	32	111	178	322
4. Heat Treatment in November and January	-	0.7	45	130	293	418	-	0.8	27	74	173	317

It can be concluded that the amount of sprout development depends on the amount of heat treatment given to the seed tubers. The double heat treatment thus always tended to produce a more vigorous plant growth in the early stages than a single dose of heat treatment, the latter in turn more than the continuous cold storage treatment.

III. Number of Above-ground Stems and Tubers per Hill

The number of main-stems per hill was averaged from plants lifted at first three dates of sampling, as shown in Table 93, while the number of above-ground stems per hill was averaged from all dates of sampling as shown in Table 94. However, the number of tubers was averaged only from plants lifted at last four dates of sampling as shown in Table 95, because the average number of tubers per hill was little higher at the first two dates of lifting. This was applied for all the 14 treatments in Sub-experiment 1.

TABLE 10

Sub-Experiment 1, 1959-60

Average Number of Above-ground Stems and Tubers per Hill

Treatment Applied to Tubers Stored at 40°F During Winter	Arran Pilot		Majestic	
	Above-Ground Stems[1]	Tubers[2]	Above-Ground Stems	Tubers
1. No Heat Treatment	9.7	26.4	5.0	26.0
2. Heat Treatment in November	9.5	22.0	5.6	23.9
3. Heat Treatment in January	8.7	21.8	5.8	26.6
4. Heat Treatment in November and January.	9.3	22.5	5.7	25.3

[1]Above-ground Stems: (See Table 12).
[2]Tubers: (See Table 12).

Table 10 shows that there was apparently not much difference in the number of above-ground stems and tubers per hill as a result of heat treatment. However, cold storage treatment showed a tendency to give a higher number of above-ground stems and tubers per hill in Arran Pilot. On the other hand, heat treatment gave a slight increase in the number of stalks per hill in Majestic, but the difference was marginal.

(iv) Development of Main-Stems from Different Regions of the Seed Tubers

TABLE 11

Sub-Experiment 1. 1959-60

Per Cent Main-Stems Developed on Different Regions of the Seed Tubers. (Date of First Two Samples)

Treatment Applied to Tubers Stored at 40°F During Winter	Arran Pilot			Majestic		
	A.R.[1]	M.R.[2]	H.R.[3]	A.R.	M.R.	H.R.
1. No Heat Treatment	57.3	40.0	2.7	77.5	14.3	8.2
2. Heat Treatment in November	71.9	22.9	5.2	78.3	15.2	6.5
3. Heat Treatment in January	76.7	21.1	2.2	67.8	16.9	5.3
4. Heat Treatment in November and January	94.4	3.3	2.3	74.1	18.5	7.4

[1] A.R. - Apical Region
[2] M.R. - Middle Region
[3] H.R. - Heel Region

Continuous cold storage and cold storage plus heat treatment produced multiple sprouting during the storage period, but when the tubers were planted in the field, the maximum proportion of main-stems (sprouts developed into stems) developed from the apical region. Sprouts on the middle or heel regions seldom developed into main-stems; instead they remained suppressed.

(v) Relationship Between Number of Sprouts, Main-Stems, Above-Ground Stems and Tubers

TABLE 12

Sub-Experiment 1, 1959-60

Relationship Between the Number of Sprouts, Main-Stems, Above-ground Stems and Tubers

Treatment Applied To Tubers Stored at 40°F During Winter	Arran Pilot					Majestic				
	Sprouts[1] per Seed Tuber	Main-Stems[2] per Hill	Above-Ground Stems[3] per Hill	Tubers[4] per Hill	Tubers per Main-Stem	Sprouts Per Seed Tuber	Main Stems Per Hill	Above-Ground Stems per Hill	Tubers Per Hill	Tubers per Main-Stem
1. No Heat Treatment	17.9	6.3	9.7	26.4	4.2	8.9	4.7	5.0	26.0	5.5
2. Heat Treatment in November	17.1	7.7	9.5	22.0	2.8	12.1	4.6	5.6	23.9	5.2
3. Heat Treatment in January	17.4	6.8	8.7	21.8	3.2	18.5	5.0	5.8	26.6	5.3
4. Heat Treatment in November and January	18.9	5.8	9.3	22.5	3.9	17.0	4.9	5.7	25.3	5.1

[1] Sprouts: Average of 10 Seed Tubers

[2] Main-Stem: Average of 10 plants of first three samples (See Table 93 in the Appendix)

[3] Above-ground Stems: Average of 10 plants of first three samples (See Table 94 in the Appendix)

[4] Tubers: Average of 16 plants of last four samples (See Table 95 in the Appendix).

From Table 12, it appears that heat treatment did not change much the number of sprouts per seed tuber in Arran Pilot, whereas it did in Majestic. Arran Pilot always produced more main-stems than Majestic, but fewer tubers per main-stem. A relationship between the number of sprouts, Main-stems, above-ground stems and tubers will be shown graphically later in this section when all the fourteen treatments are considered together.

(b) Effect of Chitting - Experiment 1, 1959-60

(i) Plant Emergence

The effect of continuous chitting and chitting from February, on the rate of plant emergence is shown in Table 13.

TABLE 13

Experiment 1, 1959-60

Number of Plants per Plot Emerged on 26.5.1960 (27 days after Planting) as Influenced by Chitting

Treatment Applied to Tubers Stored at 40°F During Winter	Arran Pilot	Majestic	Mean
5. Chitted February-April	17.8	11.7	14.7
6. Heat Treatment in November and Chitted February-April	17.0	12.8	14.9
7. Heat Treatment in January and Chitted February-April	18.0	18.0	18.0
8. Chitted October-April	14.2	15.3	14.7
S.E.	± 2.5	± 2.5	± 1.8

On the average, heat treatment plus chitting in February resulted in slightly more plants than continuous cold storage treatment followed by chitting. Plants from seed tubers which were subjected to heat treatment in January emerged faster than those which were treated in November.

On the average continuous sprouting in the glasshouse lowered the plant emergence, this being well marked in Arran Pilot. This was perhaps due to the excessive growth in this variety, which resulted in shrinkage, and also perhaps due to the severe aphis attack.

The average effect of chitting and Non-chitting on the rate of plant emergence is given in Table 14. The two varieties responded differently.

TABLE 14

Experiment 1, 1959-60

Number of Plants Per Plot Emerged on 26.5.60 (27 Days After Planting) as Influenced by Chitting from February-April

Treatment	Arran Pilot				Majestic			
	40°F	Heat treatment in Nov.	Heat Treatment in Jan.	Av.	40°F	Heat Treatment in Nov.	Heat Treatment in Jan.	Av.
No Chitting	14.0	23.7	24.3	20.7	0.2	1.3	4.5	2.0
Chitting from February	17.7	17.0	18.0	17.6	11.7	12.8	18.0	14.2

Chitting resulted in faster emergence of plants in Majestic while it reduced it in Arran Pilot. A severe attack of aphis on the long sprouts of Arran Pilot might have delayed the emergence.

(ii) Weight of Dry Matter (g.) in Foliage and Tubers - Sub-Experiment 1, 1959-60

TABLE 15

Sub-Experiment 1, 1959-60

Dry Matter (g.) Changes at Different Stages of Plant Growth (Average of 4 Hills).

Weight of Foliage (g.) Per Hill

Treatment Applied to Tubers Stored at 40°F. During Winter	Arran Pilot						Majestic					
	June 8	June 23	July 8	July 23	Aug. 8	Aug. 23	June 8	June 23	July 8	July 23	Aug. 8	Aug. 23
5. Chitted February-April	3	17	-	74	-	300	4	23	33	85	122	143
6. Heat Treatment in November and Chitted February-April	4	21	3	-	42	96	5	14	-	41	128	77
7. Heat Treatment in January and chitted February-April	3	11	-	45	-	63	4	26	-	91	137	133
8. Chitted October-April	1	12	-	25	-	66	4	20	41	-	121	88

Weight of Tubers (g.) per Hill

Treatment	June 8	June 23	July 8	July 23	Aug. 8	Aug. 23	June 8	June 23	July 8	July 23	Aug. 8	Aug. 23
5. Chitted February-April	-	2	-	41	-	270	-	0.7	5	91	206	330
6. Heat Treatment in November and Chitted February-April	0.1	3	0.5	-	72	172	-	0.7	-	36	168	161
7. Heat Treatment in January and Chitted February-April	0.6	-	-	66	-	202	-	2	-	90	239	308
8. Chitted October-April	1	4	-	8	-	12	-	0.5	35	-	176	202

The data in Table 15 is not adequate to draw any specific conclusion as there was lot of blanking (missing plants due to leaf-roll). Most of the figures in the Table are averages of less than four plants (sometimes a single plant). But differences in behaviour can be seen from the Table. Although the continuous chitting treatment gave early tuberization, the yield of foliage and tuber sets was far lower than from the February chitted tubers. It would be hard to conclude whether heat treatment followed by chitting had any response in increasing the yield of foliage or tubers.

(iii) Number of Above-Ground Stems and Tubers per Hill

TABLE 16

Sub-Experiment 1, 1959-60

Average Number of Above-Ground Stems and Tubers per Hill

Treatment Applied to Tubers Stored at 40°F During Winter	Arran Pilot		Majestic	
	Above-Ground Stems[1]	Tubers[2]	Above-Ground Stems	Tubers
5. Chitted February-April	3.9	15.0	5.3	20.0
6. Heat Treatment in November and Chitted February-April	5.8	11.0	4.0	10.0
7. Heat Treatment in January and Chitted February-April	3.7	9.0	4.4	14.3
8. Chitted October-April	3.1	5.0	3.6	14.5

[1]Above-ground Stems: (See Table 12)

[2]Tubers: (See Table 12)

Table 16 shows that seed tubers chitted all through produced fewer above-ground stems per hill than those chitted from February, the latter being in the multiple sprouting phase. Heat treatment followed by chitting in February did not show any sharp difference in the number of above-ground stems per hill from those without heat treatment, followed by chitting. Also, seed chitted for the long period developed only 5.0 tubers per hill in Arran Pilot, but 14.5 in Majestic. The very low number in Arran Pilot could be due to shrivelling of the seed tubers and the development of very long sprouts during the chitting period in the glasshouse. The size of the tubers resulting from long chitting treatment was always larger than those obtained from the February chitting treatment.

Low temperature storage (40°F) followed by chitting from February until planting resulted in the largest number of tubers per hill in Majestic (i.e. 20 tubers per hill) which could be due to a lower infection of leaf-roll.

(iv) Development of Main-Stems from Different Regions of the Seed Tubers

TABLE 17

Sub-Experiment 1, 1959-60

Per Cent Main-Stems Developed on Different Regions of the Seed Tubers. (Data of First Two Samples)

Treatment Applied to Tubers Stored at 40°F During Winter	Arran Pilot			Majestic		
	A.R.	M.R.	H.R.	A.R.	M.R.	H.R.
5. Chitted February-April	82.9	9.7	7.4	66.0	28.0	6.0
6. Heat Treatment in November and Chitted February-April	59.3	33.9	6.8	69.6	23.9	6.5
7. Heat Treatment in January and Chitted February-April	68.9	24.0	7.1	85.7	11.9	2.3
8. Chitted October-April	100.0	-	-	51.4	34.2	14.4

Seed tubers chitted all through were in the apically dominant phase during the storage period, and continued in this phase after planting in the field. But February chitted seed tubers, which were in the multiple sprouting during the storage period, also exhibited apical dominance when planted in the field, and the maximum proportion of the main-stems developed from the apical region, as seen in Table 17.

(v) Relationship Between Number of Sprouts, Main-Stems, above-Ground Stems and Tubers

Table 18 shows that the number of sprouts per seed tuber decreased with heat treatment (November and January) followed by chitting, as compared with no heat treatment plus chitting in Arran Pilot, whereas it increased it in Majestic. The number of main-stems and above-ground stems was not much affected by the heat treatment in either variety. Also, the average number of tubers per hill was lowered with heat treatment (November or January) followed by chitting as compared with no heat treatment plus chitting in both varieties.

TABLE 18

Sub-Experiment 1, 1959-60

Relationship Between the Number of Sprouts, Main-Stems, Above-Ground Stems and Tubers

	Arran Pilot					Majestic				
Treatment Applied to Tubers Stored at 40°F During Winter	Sprouts[1] per Seed Tuber	Main Stems per Hill	Above-Ground Stems[3] per Hill	Tubers[4] per Hill	Tubers per Main Stem	Sprouts per Seed Tuber	Main-Stems per Hill	Above-Ground Stems per Hill	Tubers per Hill	Tubers per Main Stem
5. Chitted February-April	16.3	3.3	3.9	15.0	4.5	13.6	2.4	3.7	20.0	8.3
6. Heat Treatment in November and Chitted February-April	14.2	3.3	5.8	11.0	3.3	14.3	2.0	2.6	10.5	5.2
7. Heat Treatment in January and Chitted February-April	13.9	2.0	3.7	9.0	4.5	17.3	1.4	3.2	14.3	10.2
8. Chitted October-April	3.6	0.5	3.1	5.0	10.0	13.0	0.8	4.0	14.5	18.1

1,2,3,4, See Table 12.

The average number of tubers per hill decreased considerably in Arran Pilot due to chitting seed tubers for the whole period, whereas in Majestic it did not. However, seed tubers chitted all through resulted in many more tubers per main-stem in each variety.

Effect of Storage in the Dark and Subsequent Chitting - Experiment 1, 1959-60

(i) Plant Emergence

From Table 19 it can be said that the two varieties reacted very differently in the rate of emergence of plants. Irrespective of type of treatment, Majestic gave earlier emergence than Arran Pilot, though one would expect earlier emergence from the early variety Arran Pilot. Early sprouting in Arran Pilot under high temperature in the glasshouse resulted in shrinkage at an early period of storage. After planting the seed tubers did not develop properly. Many of them rotted in the soil.

TABLE 19

Experiment 1, 1959-60

Number of Plants per Plot Emerged on 26.5.60 (27 days after Planting) as Influenced by Dark Treatment Followed by Desprouting

Treatment Applied to Tubers Stored in the Dark	Arran Pilot	Majestic	Mean
9. No Desprouting	4.7	11.3	8.0
10. Desprouted once before Planting	0.0	0.8	0.4
11. Desprouted twice. 20th. February and 14th. March.	10.7	17.0	13.7
S.E.	± 2.5	±2.5	± 1.8

Desprouting before planting delayed plant emergence, probably because the potentiality of the seed tuber to further sprouting was weakened considerably. The undesprouted seed tubers had such large sprouts at planting, that they did not grow properly in the soil. Those given a double desprouting treatment emerged earlier than the others, because the second desprouting was done in the middle of March after which they were chitted in the light for about six weeks before planting.

(ii) Weight of Dry Matter (g.) in Foliage and Tubers - Sub-Experiment 1, 1959-60

TABLE 20

Sub-Experiment 1, 1959-60

Dry Matter (g.) Changes at Different Stages of Plant Growth. (Average of 4 Hills).

Weight of Foliage (g.) per Hill

Treatment Applied to Tubers Stored in the Dark	Arran Pilot						Majestic					
	June 8	June 23	July 8	July 23	Aug. 8	Aug. 23	June 8	June 23	July 8	July 23	Aug. 8	Aug. 23
9. No Desprouting	0.6	2	3	2	13	38	2	19	37	72	75	77
10. Desprouted Once Before Planting	0.3	1	7	49	47	10	2	11	21	95	90	110
11. Desprouted twice. 20th. February and 14th. March	3	1	28	-	1	64	4	21	44	-	145	142

Weight of Tubers (g.) per Hill

Treatment Applied to Tubers Stored in the Dark	Arran Pilot						Majestic					
	June 8	June 23	July 8	July 23	Aug. 8	Aug. 23	June 8	June 23	July 8	July 23	Aug. 8	Aug. 23
9. No Desprouting	1	2	2	3	15	227	-	0.5	21	67	94	170
10. Desprouted Once Before Planting	0.5	0.1	5	62	70	20	-	0.3	14	86	130	216
11. Desprouted twice, 20th. February and 14th. March.	2	7	29	-	7	318	-	0.7	34	-	230	316

Changes in the dry matter yield with various dates of sampling are shown in Table 20. Due to the study of an unequal number of plants, the results obtained are variable, and it would be hard to conclude much from them. However, it can be said that plants from double desprouted seed tubers yielded more foliage and tubers than those from undesprouted or single desprouted treatment at all dates of sampling. This increase in growth might be due to the effect of chitting for about six weeks after the second desprouting.

(iii) Number of Above-Ground Stems and Tubers per Hill

Table 21 shows that the two varieties responded differently in the development of above-ground stems and tubers per hill. Desprouting once before planting resulted in the greatest number of above-ground stems per hill in Majestic, while in Arran Pilot the greatest number of above-ground stems was obtained from the undesprouted tubers. On the basis of work done by several authors (74, 75, 169), desprouting should produce more above-ground stems per hill.

TABLE 21

Sub-Experiment 1, 1959-60

Average Number of Above-Ground Stems and Tubers per Hill

Treatment Applied to Tubers Stored in the Dark	Arran Pilot		Majestic	
	Above-Ground Stems[1]	Tubers[2]	Above-Ground Stems	Tubers
9. No Desprouting	4.9	3.0	4.7	21.7
10. Desprouted Once Before Planting	3.5	4.1	12.1	21.6
11. Desprouted twice, 20th. February and 14th. March.	1.6	3.0	8.0	20.5

1,2 (Table 12)

Why Arran Pilot behaved differently may be due to the severe shrinkage of the seed tubers, which resulted from the growth of long sprouts. The more the desprouting in this variety, the greater was the depletion of substrate and hence a reduction in the number of above-ground stems per hill. The number of tubers per hill also decreased considerably with each of the treatments in Arran Pilot. With Majestic, the number of tubers per hill was more or less the same in each treatment.

(IV) Development of Main-Stems from Different Regions of the Seed Tubers

Desprouting did not affect the number of main-stems produced by the three regions of the seed tubers, but double desprouting markedly increased the number produced by the middle regions at the expense of the apex in both varieties (Table 22).

TABLE 22

Sub-Experiment 1, 1959-60

Per Cent Main-Stems Developed on Different Regions of the Seed Tubers

(Data of First Two Samples)

Treatment Applied to Tubers Stored in the Dark	Arran Pilot			Majestic		
	A.R.	M.R.	H.R.	A.R.	M.R.	H.R.
9. No Desprouting	55.5	37.0	7.5	61.3	25.8	12.9
10. Desprouted once before Planting	58.3	25.0	16.7	45.2	38.1	16.7
11. Desprouted twice, 20th. February and 14th. March	18.2	72.7	9.1	13.8	75.9	10.3

(v) Relationship Between Number of Sprouts, Main-Stems, Above-Ground Stems and Tubers.

Although double desprouting resulted in the production of a larger number of sprouts, fewer of them survived to produce main-stems in Arran Pilot (Table 23). This severe reduction in the number of main-stems by double desprouting is associated with the condition of the seed tubers, which, when desprouted the second time in the middle of March, seldom developed any above-ground stems. In Majestic, however, double desprouting gave more sprouts and main-stems than undesprouted seed tubers, although the increase was marginal. Desprouting twice, produced the maximum number of tubers per main-stem in Arran Pilot and the second larger number in Majestic.

TABLE 23

Sub-Experiment 1, 1959-60

Relationship Between the Number of Sprouts, Main-Stems, Above-Ground Stems and Tubers

Treatment Applied to Tubers Stored in the Dark	Arran Pilot					Majestic				
	Sprouts[1] per Seed Tuber	Main-Stems[2] per Hill	Above-ground Stems[3] per Hill	Tubers[4] per Hill	Tubers per Main-Stem	Sprouts per Seed Tuber	Main-Stems per Hill	Above-Ground Stems per Hill	Tubers per Hill	Tubers per Main-Stem
9. No Desprouting	8.1	4.2	4.9	4.7	1.1	13.7	2.1	3.0	21.7	10.3
10. Desprouted once before Planting	-	2.4	3.5	12.1	5.0	-	3.6	4.1	21.6	6.0
11. Desprouted twice, 2oth. February and 14th. March	16.9	1.1	1.6	8.0	7.3	14.0	2.7	3.0	20.5	7.6

1, 2, 3, 4: See Table 12

This increase in the number of tubers per main stem could be due to the effect of chitting for about six weeks after the second desprouting, which developed more stolon bearing underground branches than in the undesprouted seed tubers. The highest number of seed tubers per main-stem from undesprouted seed tubers in Majestic might have been due to more stolon bearing underground branches which had resulted from the blackening of the tip of the sprout.

Effect of Storage in Pit Followed by Chitting and Desprouting-
Experiment 1, 1959-60

(i) Plant Emergence

TABLE 24

Experiment 1, 1959-60

Number of Plants per Plot Emerged on 26.5.1960 (27 days after Planting) As Influenced by Storage in Pit Followed by Chitting

Treatment Applied to Tubers Stored in a Pit	Arran Pilot	Majestic	Mean
12. No Desprouting Before Planting	18.2	5.8	12.0
13. Desprouted Before Planting	8.2	2.8	5.5
14. Chitted February-April After Desprouting Arran Pilot	18.5	17.5	18.0
S.E.	± 2.5	± 2.5	±1.8

Table 24 shows that plants from sprouted seed tubers came up first in each variety. The next in order were plants from the undesprouted seed tubers. Desprouting before planting caused late emergence in both varieties presumably because growth of new sprouts took quite a while.

(ii) Weight of Dry Matter (g.) in Foliage and Tubers - Sub-Experiment 1, 1959-60

The figures in Table 25 show that seed tubers sprouted from February, resulted in heavier growth of foliage up to June 23rd. in both varieties. But in the later part of the growing season, i.e. from July 23rd. on, plants from undesprouted and desprouted seed tubers gave a higher yield of dry matter than those of sprouted seed tubers. Similarly the yield of dry matter of tubers increased in the sprouted treatment at an early stage of plant growth, which is more apparent in Majestic than Arran Pilot. Also the desprouting treatment delayed tuberization and therefore gave a lower yield of tubers than the undesprouted treatment at the first sampling. The higher yield of tubers from the undesprouting treatment is due to an increase in the average size of the tubers produced.

TABLE 25

Sub-Experiment 1, 1959-60

Dry Matter (g.) Changes at Different Stages of Plant Growth (Average 4 Hills)

Weight of Foliage (g.) per Hill

Treatment Applied to Tubers Stored in a Pit	Arran Pilot						Majestic					
	June 8	June 23	July 8	July 23	Aug. 8	Aug. 23	June 8	June 23	July 8	July 23	Aug. 8	Aug. 23
12. No Desprouting before Planting	2	23	55	97	157	180	3	25	64	103	126	144
13. Desprouted before Planting	3	21	43	107	150	188	4	16	61	102	146	138
14. Chitted February-April	5	39	44	56	90	98	6	29	63	103	114	123
Weight of Tubers (g.) per Hill												
12. No Desprouting before Planting	-	2	32	110	263	417	-	0.1	28	103	207	321
13. Desprouted before Planting	-	0.1	14	79	248	325	-	0.05	28	94	197	300
14. Chitted February-April	-	2	23	108	294	298	-	1	31	90	230	313

(iii) Number of Above-Ground Stems and Tubers per Hill

Table 26 shows that chitting after desprouting in Arran Pilot resulted in the greatest number of above-ground stems per hill in both varieties. Desprouting resulted in slightly more above-ground stems than no desprouting in Arran Pilot but slightly less in Majestic. A reduction in the number of above-ground stems in Majestic is contrary to the results of several authors (74, 75, 169) and this must be explained here. Actually the sprout length of Majestic was so small during the desprouting operation that only a few sprouts (0.5 - 1.0 cm.) were knocked off and this did not give any marked difference in the number of above-ground stems.

TABLE 26

Sub-Experiment 1, 1959-60

Average Number of Above-Ground Stems and Tubers per Hill

Treatment Applied to Tubers Stored in a Pit	Arran Pilot		Majestic	
	Above-Ground Stems[1]	Tubers[2]	Above-Ground Stems	Tubers
12. No Desprouting Before Planting	6.5	15.8	5.1	24.2
13. Desprouted Before Planting	7.1	17.0	4.1	23.2
14. Chitted February-April After Desprouting Arran Pilot	7.3	14.0	5.4	16.6

[1]Above-Ground Stems: See Table 12

[2]Tubers: See Table 12

The number of tubers per hill was related to the number of above-ground stems per hill in the desprouting and no desprouting treatments. In other words, the number of tubers increased as the number of above-ground stems increased in these two treatments. Plants from chitted seed tubers resulted in the greatest number of above-ground stems per hill in each variety, but the least number of tubers per hill which should be explained here. Sprouted seed tubers developed fewer main-stems per hill (see Table 28) but more underground branches than the other two treatments. Some of the underground branches bore hardly any stolons, but were of course counted in the number of above-ground stems. This result therefore suggests that the number of tubers per hill is controlled mainly by the number of main-stems per hill and not by the number of above-ground stems.

(iv) Development of Main-Stems from Different Regions of the Seed Tubers

TABLE 27

Sub-Experiment 1, 1959-60

Per Cent Main-Stems Developed on Different Regions of the Seed Tubers. (Data of First Two Samples)

Treatment Applied to Tubers Stored in a Pit	Arran Pilot			Majestic		
	A.R.	M.R.	H.R.	A.R.	M.R.	H.R.
12. No Desprouting Before Planting	63.5	33.3	3.2	60.4	32.1	7.5
13. Desprouted Before Planting	70.8	29.2	-	66.7	26.7	6.6
14. Chitted February-April After Desprouting Arran Pilot	65.8	25.0	9.2	82.1	14.3	3.6

Although each of the three treatments exhibited the multiple sprouting phase during the storage period, none of them maintained such a growth phase (multiple sprouting) in the field. Instead, the maximum proportion of main-stems were always found to develop from the apical region of the seed tubers (See Table 27).

(v) Relationship Between Number of Sprouts, Main-Stems, Above-Ground Stems and Tubers

Table 28 shows that chitting slightly increased the number of sprouts per seed tuber from no chitting, in both varieties, but the number of main-stems per hill was higher in the unsprouted seed tubers than in the chitted ones. On the other hand, the number of above-ground stems per hill was greater in chitted seed tubers in both varieties due to the development of more underground branches. The number of tubers per hill was higher in the unsprouted treatment, than the sprouted ones, the reasons for which have already been discussed in this chapter.

TABLE 28

Sub-Experiment 1, 1959-60

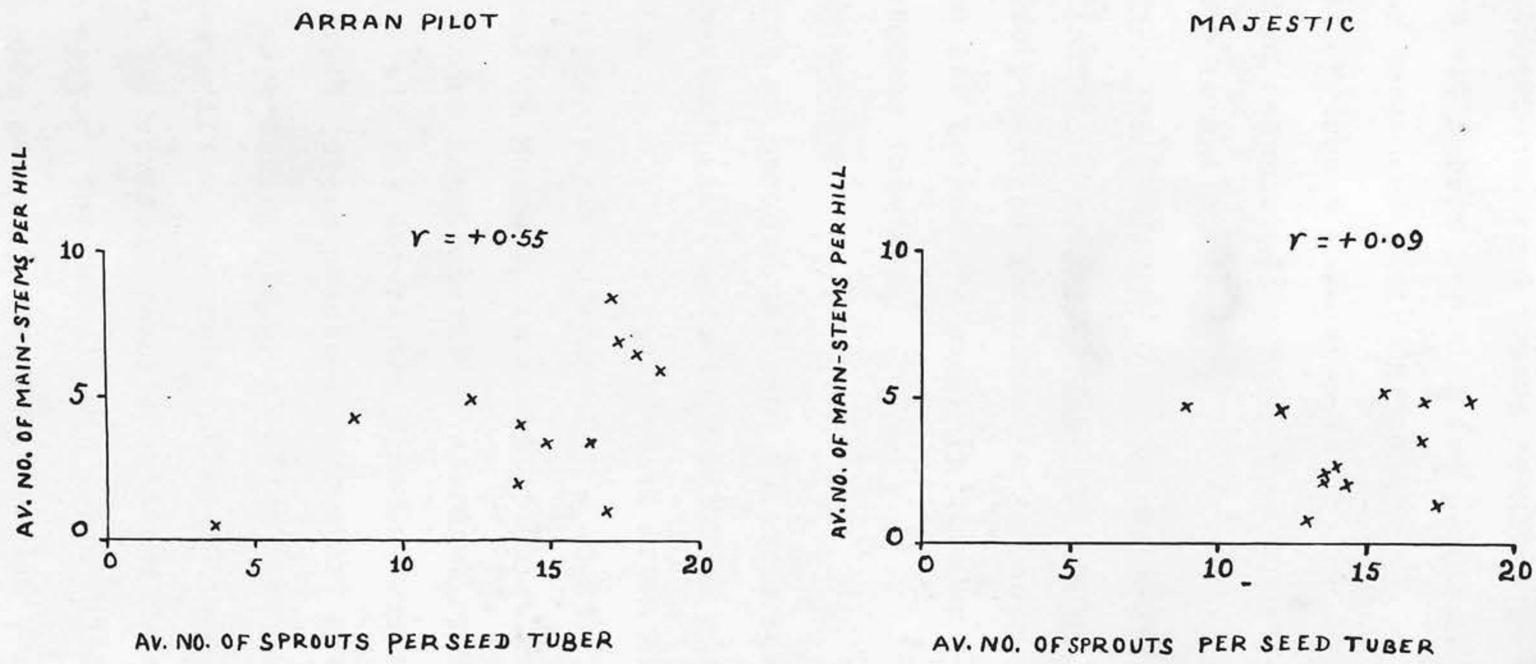
Relationship Between the Number of Sprouts, Main-Stems, Above-Ground Stems and Tubers

Treatment Applied to Tubers Stored in a Pit	Arran Pilot					Majestic				
	Sprouts[1] per Seed Tuber	Main Stems[2] per Hill	Above-Aground Stems[3] per Hill	Tubers[4] per Hill	Tubers per Main Stem	Sprouts per Seed Tuber	Main-Stems per Hill	Above-Ground Stems per Hill	Tubers per Hill	Tubers per Main-Stem
12. No Desprouting Before Planting	12.3	4.9	6.5	15.8	3.2	15.5	5.2	5.3	24.2	4.6
13. Desprouted before Planting	-	5.0	7.1	17.0	3.4	-	4.0	4.1	23.2	5.4
14. Chitted February-April after desprouting Arran Pilot	14.0	4.0	7.3	14.0	3.5	16.9	3.5	5.4	16.6	4.7

1, 2, 3, 4: See Table 12

SUB-EXPERIMENT 1, 1959-60

Fig. 1 RELATIONSHIP BETWEEN NUMBER OF SPROUTS PER SEED TUBER AND NUMBER OF MAIN-STEMS PER HILL (EACH POINT REPRESENTING A TREATMENT MEAN)



Undoubtedly, the desprouted seed tubers resulted in more main-stems, above-ground stems and tubers per hill (or per main-stem) than the no desprouting treatment in Arran Pilot. In Majestic, around 20 per cent of tubers bore sprouts of 0.5 - 1.0 cm., and these alone were desprouted. Thus the effect of desprouting in this variety is not apparent.

Relationship between the Number of Sprouts, Main-Stems, Above-Ground Stems and Tubers (based on all 14 treatments)

The relationship between the number of sprouts, main-stems, above-ground stems and tubers are shown in figures 1-4 for all the fourteen treatments together.

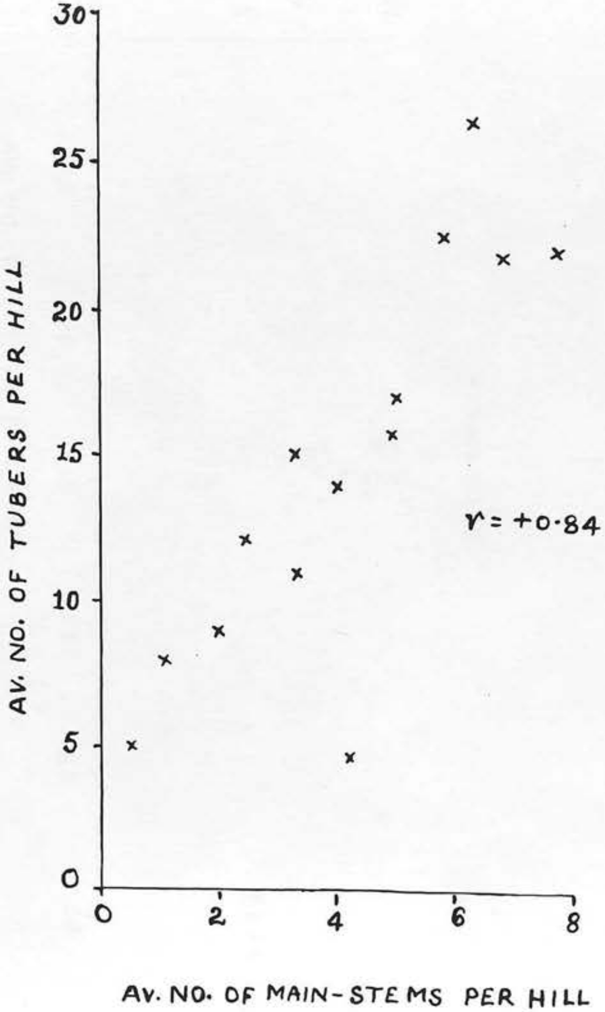
(1) Sprouts and Main-Stems

When the number of sprouts per seed tuber is compared with the number of main-stems (i.e. sprouts growing to stems) a positive correlation ($r = +0.55$) resulted in Arran Pilot, but there was no relationship for Majestic ($r = +0.09$). Why this relationship is weak in Majestic is a matter which should be explained here. Under low temperature storage, sprouting was inhibited, and not all the developing sprouts were recorded. Also the sprouted seed tubers produced many short sprouts, below 1.0 cm. which were drying off by planting time, but were recorded. The non-significant correlation co-efficient in Majestic is due to the variable results obtained from sprouting the tubers in the dark. For example, in Arran Pilot the double desprouted seed tubers gave 4.3 sprouts (over 1.0 cm) per seed tuber, but produced only 1.1 main-stems per seed tuber. During growth analysis it was noticed that the rest of the sprouts were

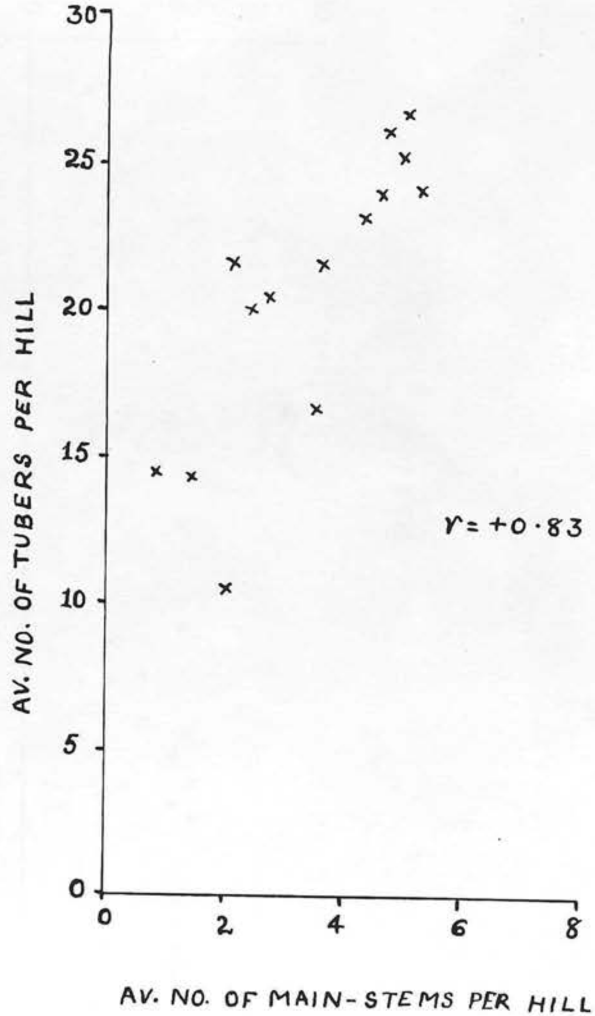
SUB-EXPERIMENT 1, 1959-60

Fig. 2 RELATIONSHIP BETWEEN NUMBER OF MAIN-STEMS AND NUMBER OF TUBERS PER HILL

(EACH POINT REPRESENTING A TREATMENT MEAN)



ARRAN PILOT



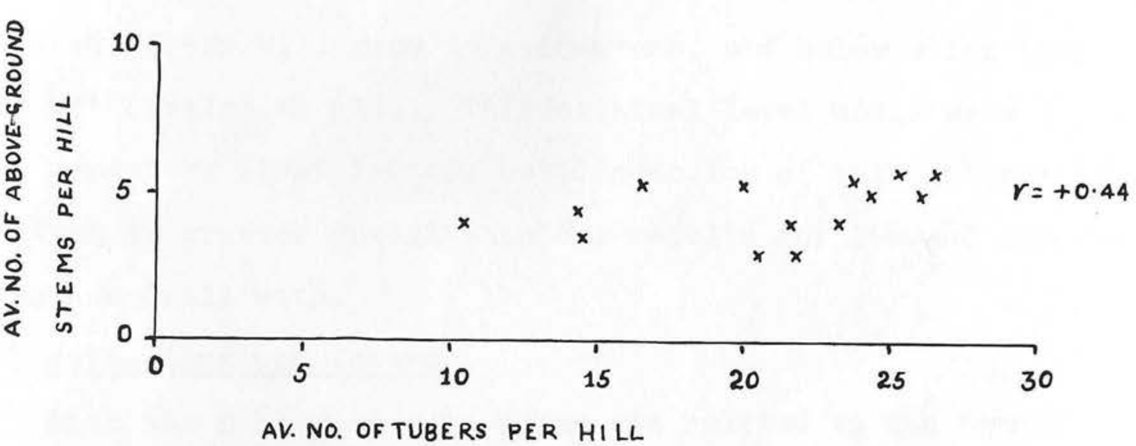
MAJESTIC

131 A

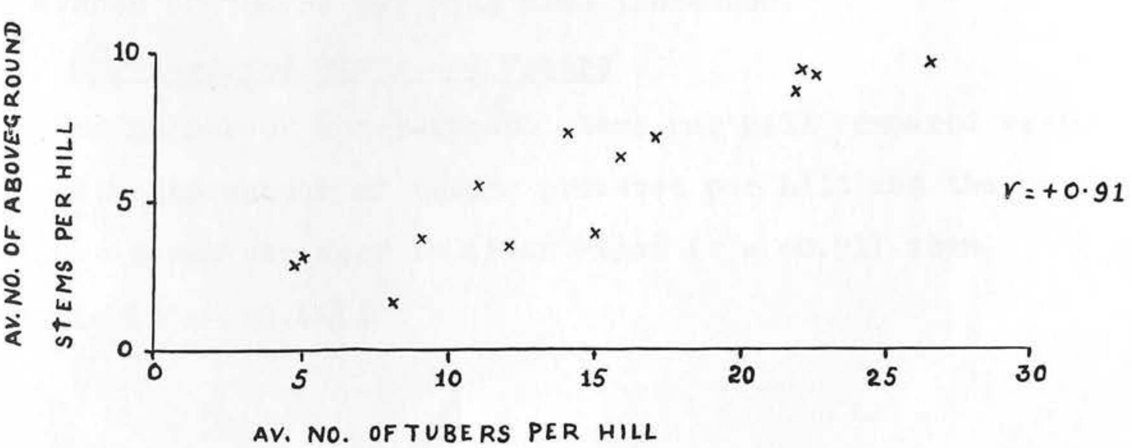
SUB-EXPERIMENT 1, 1959-60

Fig. 3 RELATIONSHIP BETWEEN NUMBER OF ABOVE-GROUND STEMS AND NUMBER OF TUBERS PER HILL (EACH POINT REPRESENTING A TREATMENT MEAN)

MAJESTIC.



ARRAN PILOT



rotting in the soil. In Majestic, seed tubers sprouted from February until planting gave always 2.5 sprouts (over 1.0 cm) per seed tuber at all levels of heat treatment, but they gave variable number of main-stems per seed tuber resulting in a poor relationship.

Whatever the difference in the results may be, there will be some critical sprout length level above which sprouts of sprouted tubers will grow to main-stems, and below which they will not develop at all. This critical level would seem to fall somewhere about 1.0 cm, but discussion of this subject will be given in greater detail when the results for 1960-61 experiments are dealt with.

(ii) Main-stems and Tubers

When the number of main-stems was related to the number of tubers per hill, there was a close positive relationship in each variety ($r = +0.84$ and $+0.83$ in Arran Pilot and Majestic respectively, which are above the significance level ($r = \pm 0.60$). This shows that as the number of main-stems per hill increased the number of tubers per hill also increased.

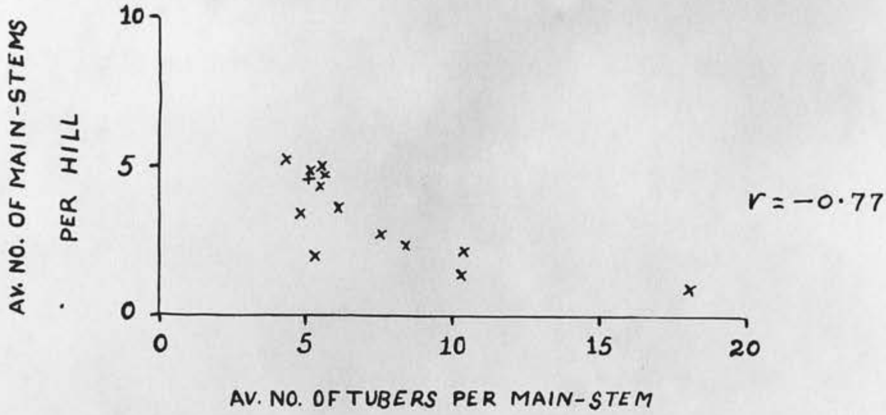
(iii) Above-ground Stems and Tubers

The number of above-ground stems per hill compared very well with the number of tubers produced per hill and the relationship was stronger in Arran Pilot ($r = +0.91$) than Majestic ($r = +0.44$).

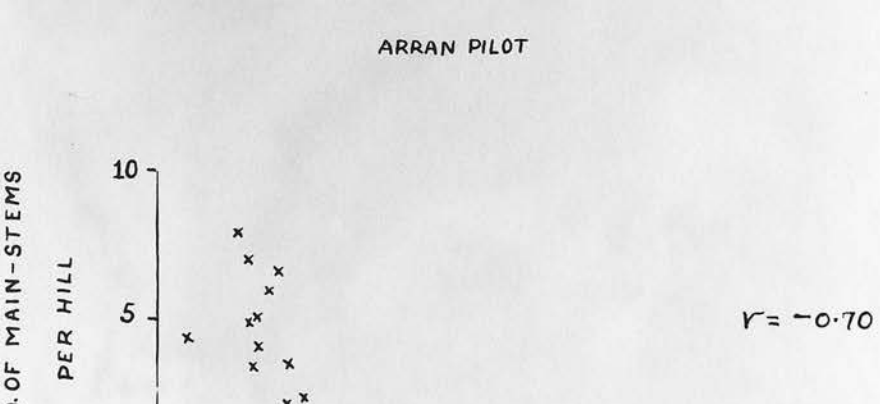
SUB-EXPERIMENT 1, 1959-60

Fig. 4 RELATIONSHIP BETWEEN NUMBER OF MAIN-STEMS PER HILL AND NUMBER OF TUBERS PER MAIN-STEM (EACH POINT REPRESENTING A TREATMENT MEAN)

MAJESTIC



ARRAN PILOT

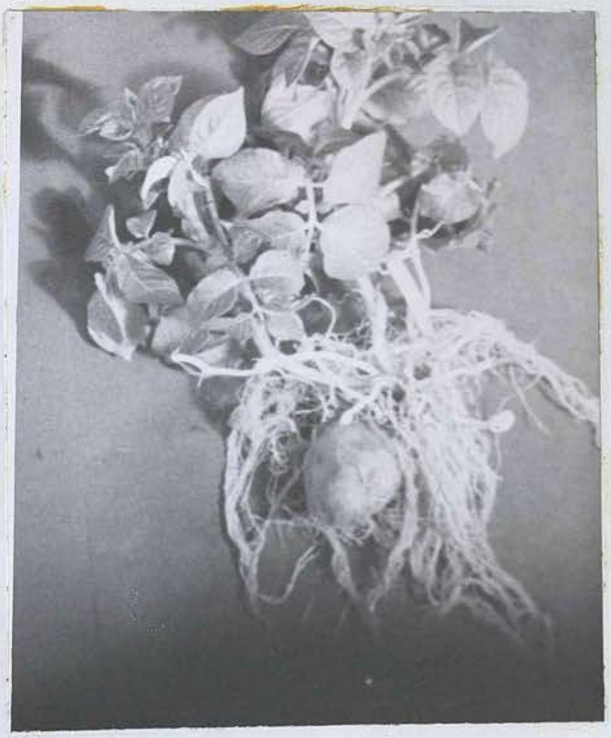


(iv) Main-Stems and Tubers per Main-Stem

On the other hand, when the number of main-stems per hill was compared with the number of tubers per main-stem, a negative correlation ($r = -0.70$ and -0.77 for Arran Pilot and Majestic respectively) was obtained which also was above the significance level. The largest number of tubers per main-stem was produced by those tubers which had been sprouted throughout the chitting period, because they produced one main-stem. The unsprouted tubers produced main-stems with fewer stolons and consequently fewer tubers per main-stem.

Arran Pilot

Tr.1. Storage at 40°F all through the storage period. Plants lifted on 8th. June, i.e. 40 days after planting.



Tr.5. Storage at 40°F till 20th. Feb.; sprouted in light in glasshouse. Plants lifted on 8th. June.

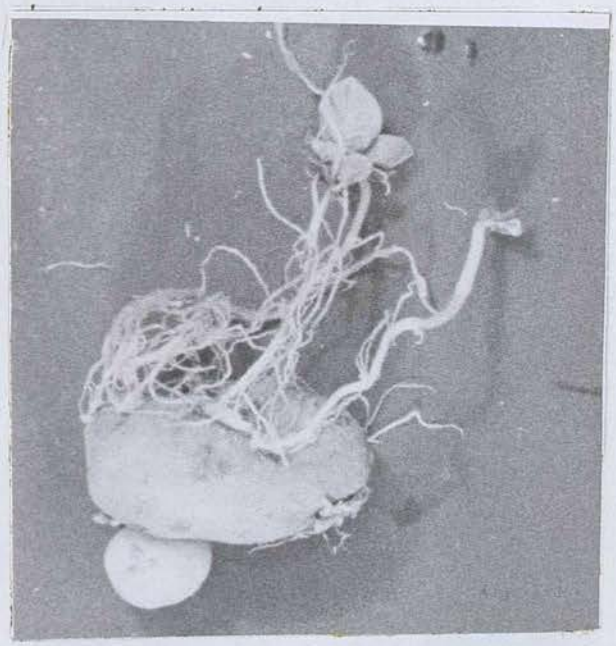
Tr.8. Sprouted in light all the storage period in glasshouse. Plants lifted on 8th. June.

PLATE IV

Arran Pilot

(Plants lifted on 8th. June,1960. i.e. 40 days after planting)

Tr.9. Sprouted in the dark all the storage period in glasshouse.



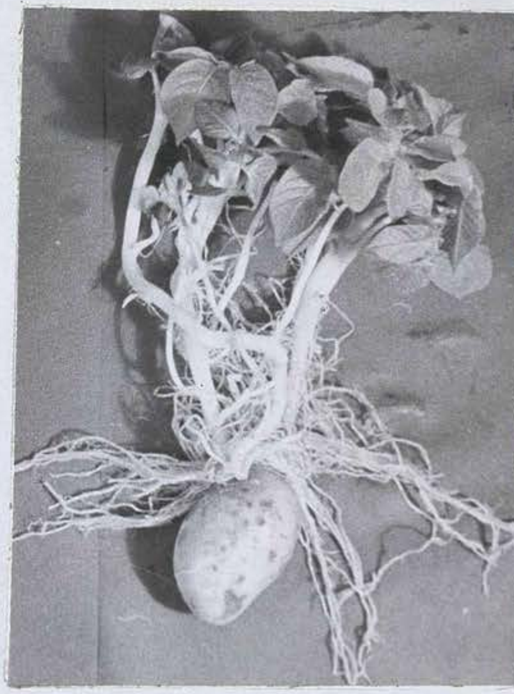
Tr.11 . Sprouted in the dark and desprouted twice (20th.Feb. and 14th. March); sprouted in light.

PLATE V

Majestic

(Plants lifted on 8th. June, 1960. i.e. 40 days after planting)

Tr.1. Storage at 40°F all through the storage period.



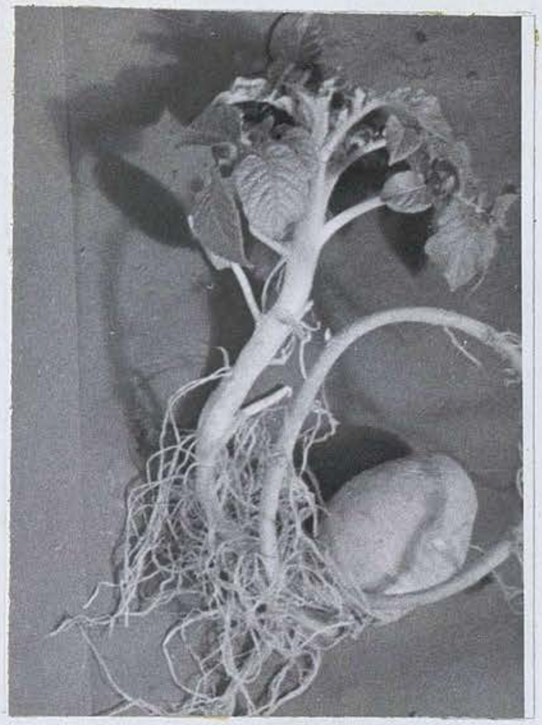
Tr.5. Storage at 40°F till 20th. Feb.; sprouted in light in glasshouse.

Tr.8. Sprouted in light all the storage period in glasshouse.

PLATE VI

Majestic

(Plants lifted on 8th. June, 1960. i.e. 40 days after planting)



Tr.9. Sprouted in the dark all the storage period in glasshouse.

Tr.11. Sprouted in the dark and desprouted twice(20th. Feb. and 14th. March); sprouted in light.

EXPERIMENT 2, 1959-60

(i) Plant Emergence:

To study the effect of different storage treatments on the rate of plant emergence, counts were made twice a week, as in Experiment 1, but only the data of the first count on May 26th. were statistically analysed, for the reasons already mentioned in Experiment 1. The analysis of variance is presented in the Appendix Table 102.

TABLE 29

Experiment 2, 1959-60

Number of Plants per Plot Emerged on 26.5.1960 (26 days after Planting) as Influenced by Period of Chitting

Dates of Chitting	Arran Pilot	Majestic	Mean
December	11.5	17.0	14.2
February	17.0	12.6	14.8
March	18.6	13.5	16.1
No Chitting	24.1	10.7	17.4
S.E.	± 1.5	± 1.5	±1.1

Table 29 shows that the two varieties significantly differed in the rate of plant emergence. Arran Pilot came up first.

The time at which the tubers were set up for chitting gave significant differences in the rate of plant emergence. The two varieties responded quite differently. Early sprouting showed a tendency for later emergence with Arran Pilot, and earlier emergence with Majestic. On the basis of work done by a series of authors (10, 24, 36, 119, 142) early sprouting should give earlier emergence. Why Arran Pilot responded differently here may be due to the following reasons. Early sprouting developed very long sprouts which resulted in shrinkage of the tubers. Also the long sprouts were severely attacked by aphis (which caused leaf-roll in the plant).

TABLE 30

Experiment 2, 1959-60

Number of Plants per Plot Emerged on 26.5.1960 (26 Days after Planting) as Influenced by TCNB Application

Methods of Storage	Arran Pilot	Majestic	Mean
TCNB	18.6	12.4	15.5
No TCNB	17.0	14.5	15.7
S.E.	± 1.1	± 1.1	± 0.8

Table 30 shows that the application of TCNB did not result in any significant difference in the rate of plant emergence.

(ii) Weight of Dry Matter (g.) in Foliage and Tubers - Sub-Experiment 2, 1959-60

The plants were harvested on June, 13th. (45 days after planting). Thereafter five more lifts were made (one every fifteen days). Table 31 shows that plants from chitted seed tubers of Arran Pilot, had formed tubers by the first sampling, while Majestic had not formed any tubers, except the plants from some long chitted seed tubers which showed some swelling at the end of stolons.

TABLE 31

Sub-Experiment 2. 1959-60.

Dry Matter (g.) Changes at Different Stages of Plant Growth (Average of 4 Hills)

Weight of Foliage (g.) per Hill

Dates of Chitting	Arran Pilot						Majestic					
	June 14	June 30	July 14	July 28	Aug. 11	Aug. 29	June 14	June 30	July 14	July 28	Aug. 11	Aug. 29
December	3	10	35	-	-	75	7	32	59	96	101	128
February	10	30	48	99	65	57	12	45	75	104	125	130
March	9	29	46	65	95	106	8	40	81	111	118	125
No Chitting	9	32	66	111	145	127	9	35	82	109	129	136
Weight of Tubers (g.) per Hill												
December	4	8	30	-	-	298	0	11	43	108	206	259
February	4	14	60	96	177	306	0	12	55	106	212	398
March	0.1	8	38	53	218	354	0	11	62	125	222	283
No Chitting	0	9	24	140	208	376	0	9	51	102	232	334

Marked differences in the dry matter yield of foliage were noted as a result of chitting period in both varieties. Plants from February chitted seed tubers gave a greater weight of foliage at an early stage (first sample), in both varieties, than those chitted at later dates. Chitting from December until planting, though it gave an early emergence, gave a lower plant weight at more or less all dates of sampling, possibly due to more infection with virus than other treatments.

No differences in the yield of foliage and tubers between plants treated with TCNB and those of untreated seed were noted, and so they were averaged to determine the effect of chitting.

Sprouted seed tubers gave varied results due to the unequal number of plants left after roguing for leaf-roll. The only data worth anything is that for the no-sprouting treatments, i.e. those free from leaf roll.

A similar procedure to that used in Experiment 1, was adopted in averaging the number of main-stems, the number of above-ground stems and the number of tubers per hill and the respective data are shown in Tables 96, 97, and 98 in the Appendix.

(iii) Number of Above-Ground Stems and Tubers per Hill

TABLE 32

Sub-Experiment 2, 1959-60

Average Number of Above-Ground Stems[1] and Tubers[2] per Hill.

Dates of Chitting	Arran Pilot				Majestic			
	No TCNB		TCNB		No TCNB		TCNB	
	Above-Ground Stems	Tubers	Above-Ground Stems	Tubers	Above-Ground Stems	Tubers	Above-Ground Stems	Tubers
December	3.1	13.0	2.4	8.3	5.3	16.0	4.5	8.0
February	6.5	11.8	6.0	12.8	5.2	15.2	4.4	17.7
March	6.7	14.8	6.2	12.6	3.0	15.7	4.1	19.5
No Chitting	6.4	12.5	6.6	15.0	3.5	15.2	4.8	20.1

[1]Above-ground Stems: See Table 97 in the Appendix

[2]Tubers: See Table 98 in the Appendix

Table 32 shows that the application of TCNB did not result in a marked difference in the number of above-ground stems per hill at any of the three dates of chitting. There was a trend for an increase in the number of above-ground stems and tubers per hill, at each successive date of chitting in both varieties, but not consistently. This agrees with the results obtained by Toosey (120).

(iv) Development of Main-Stems from Different Regions of the Seed Tubers

Table 33 shows that apically dominant seed tubers always tended to produce main-stems from the apical region in both varieties. Seed tubers, which were sprouted in February and March and were in the multiple sprouting phase during the storage period, also exhibited apical dominance when planted in the field. As a result, only occasionally did one or two main-stems develop from the middle or heel region.

TABLE 33

Sub-Experiment 2, 1959-60

Per Cent Main-Stems Developed on Different Regions of the Seed Tubers. (Date of First Two Samples).

Datesof Chitting	Arran Pilot						Majestic					
	No TCNB			TCNB			No TCNB			TCNB		
	A.R.	M.R.	H.R.	A.R.	M.R.	H.R.	A.R.	M.R.	H.R.	A.R.	M.R.	H.R.
December	78.3	21.7	-	100.0	-	-	80.4	13.7	5.9	86.3	13.7	-
February	73.8	24.6	1.6	66.7	30.4	2.9	54.1	42.6	3.3	64.1	23.1	12.8
March	72.9	15.2	11.9	75.0	12.5	12.5	80.6	12.9	6.5	68.4	21.0	10.6
No Chitting	81.2	12.5	6.3	76.2	19.0	4.8	81.1	10.8	8.1	74.5	19.1	6.4

The nature of stem development in unsprouted seed tubers was similar to that of February and March sprouted seed tubers. In other words, most of the shoots developed from the apical region.

(v) Relationship Between Number of Sprouts, Main-Stems, Above-Ground Stems and Tubers

(i) Sprouts and Main-Stems

The relationships between the number of main-stems, above-ground stems and tubers are shown in Figures 5-7.

TABLE 34

Sub-Experiment 2, 1959-60

Relationship Between the Number of Sprouts, Main-Stems, Above-Ground Stems and Tubers

Dates of Chitting	Arran Pilot									
	No TCNB					TCNB				
	Sprouts[1] per Seed Tuber	Main-Stems[2] per Hill	Above-Ground Stems[3] per Hill	Tubers[4] per Hill	Tubers per Main Stem	Sprouts per Seed Tuber	Main-Stems per Hill	Above-Ground Stems per Hill	Tubers per Hill	Tubers per Main Stem
December	6.7	1.1	3.1	13.0	4.2	11.0	1.3	2.4	8.3	3.5
February	12.0	3.9	6.5	11.8	1.8	19.4	3.3	6.0	12.8	2.1
March	14.2	2.7	6.7	14.8	2.2	19.5	3.9	6.2	12.6	2.0
No Chitting	10.0	5.0	6.4	12.5	2.0	10.2	4.9	6.6	15.0	2.3

[1]Sprouts: Average of 10 Seed Tubers.

[2]Main-stems: Average of 10 plants of first three samples (SeeTable 96 in the Appendix)

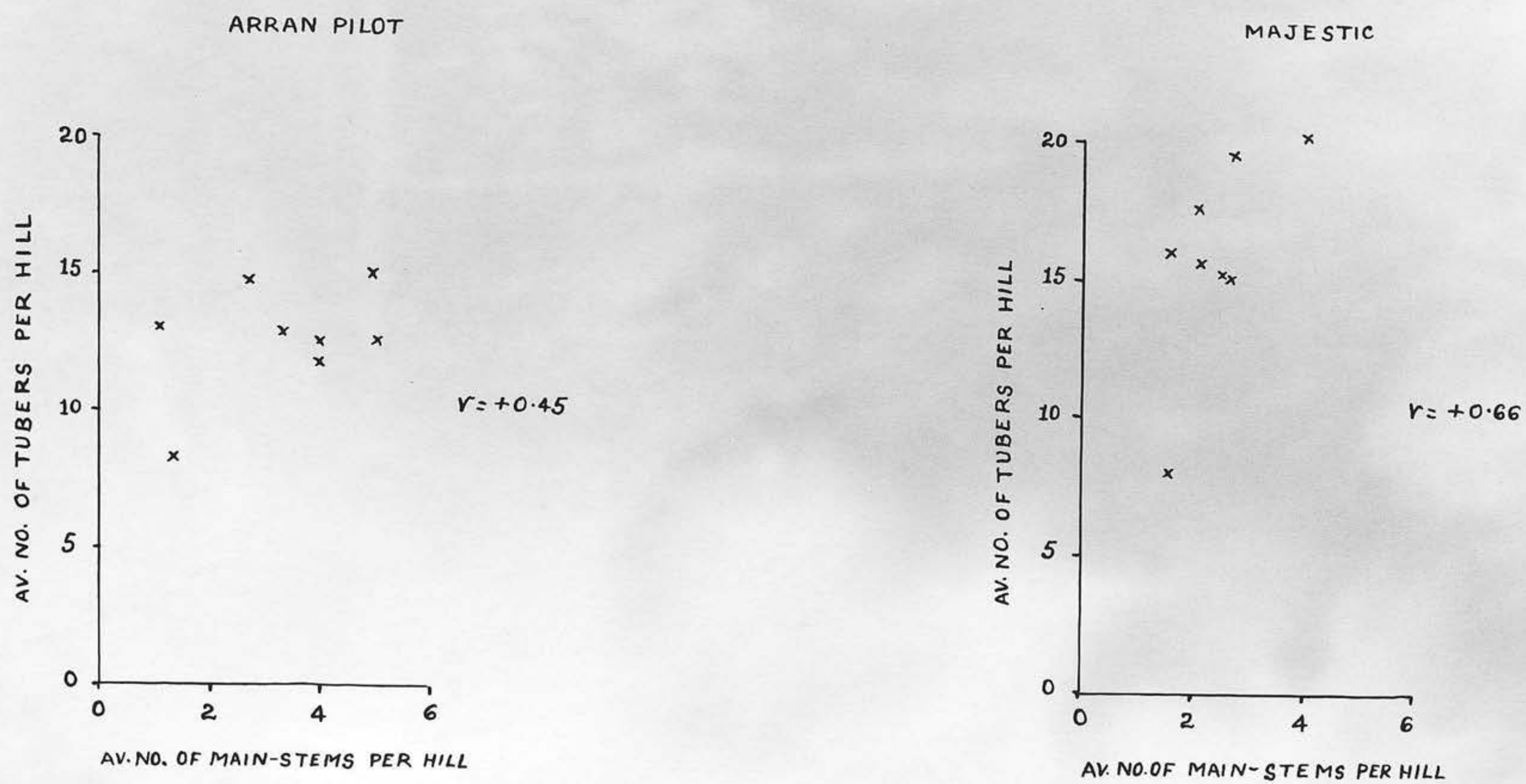
[3]Above-ground Stems: Average of 10 plants of first three samples (See Table 97 in the Appendix)

[4]Tubers: Average of 16 plants of last four samples (See Table 98 in the Appendix)

Majestic									
No TCNB					TCNB				
Sprouts per Seed Tuber	Main Stems per Hill	Above-Ground Stems per Hill	Tubers per Hill	Tubers per Main Stem	Sprouts per Seed Tuber	Main Stems per Hill	Above-Ground Stems per Hill	Tubers per Hill	Tubers per Main Stem
10.2	1.6	5.3	16.0	3.0	10.6	1.6	4.5	8.0	1.8
15.1	2.6	5.2	15.2	2.9	16.1	2.1	4.4	17.7	4.0
14.0	2.1	3.0	15.7	5.2	16.8	2.7	4.1	19.5	4.7
12.5	2.5	3.5	15.2	4.3	9.9	4.0	4.8	20.1	4.2

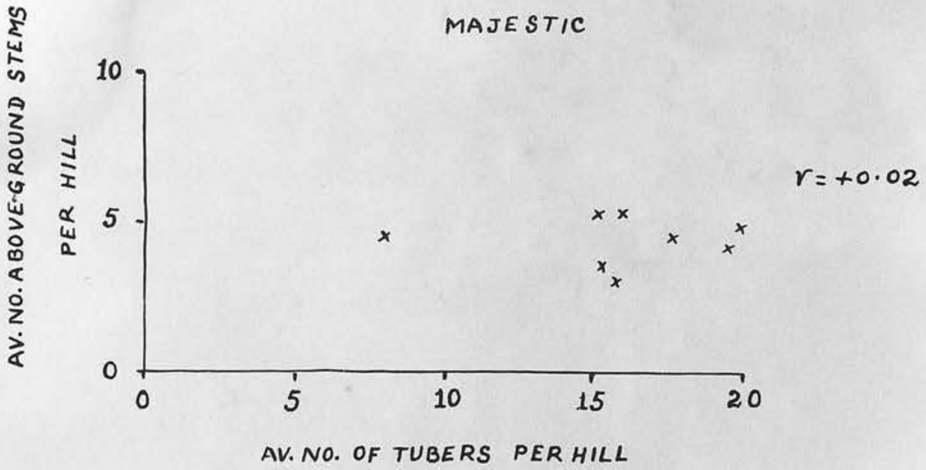
SUB-EXPERIMENT 2, 1959-60

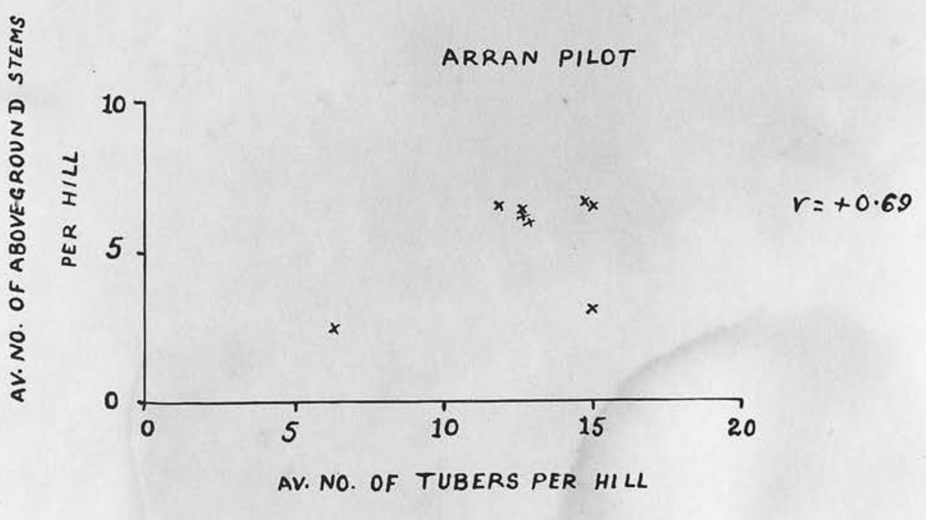
Fig. 5 RELATIONSHIP BETWEEN NUMBER OF MAIN-STEMS AND NUMBER OF TUBERS PER HILL (EACH POINT REPRESENTING A TREATMENT MEAN)



SUB-EXPERIMENT 2, 1959-60

Fig. 6 RELATIONSHIP BETWEEN NUMBER OF ABOVE-GROUND STEMS AND NUMBER OF TUBERS PER HILL (EACH POINT REPRESENTING A TREATMENT MEAN)





There is no evidence that date of sprouting influence the number of main-stems produced in both varieties (Table 34). Sometimes with an increase in the number of sprouts per seed tuber there was a reduction in the number of main-stems, which resulted in a poor relationship between the two characters ($r = +0.23$ and $+0.03$ for Arran Pilot and Majestic respectively).

However, when the number of sprouts (over 1.0 cm) was related to the number of main-stems per hill, the relationship was very strong in both varieties ($r = +0.98$ and $+0.91$ for Arran Pilot and Majestic respectively). But here, the sprouts of two dates of chitting, i.e. from December and February were considered for there was no sprouts over 1.0 cm in Majestic chitted from March, while there was only a few in Arran Pilot. This shows that only the dominant sprouts (i.e. over 1.0 cm) grew into main-stems, while the others seldom developed.

(ii) Main-Stems and Tubers

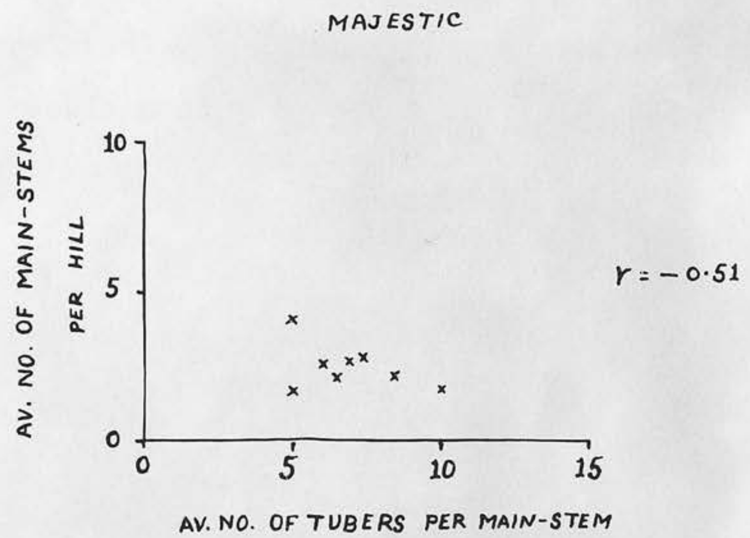
There was a positive relationship between the number of main-stems and the number of tubers produced per hill in both varieties ($r = +0.45$ and $+0.66$ for Arran Pilot and Majestic respectively).

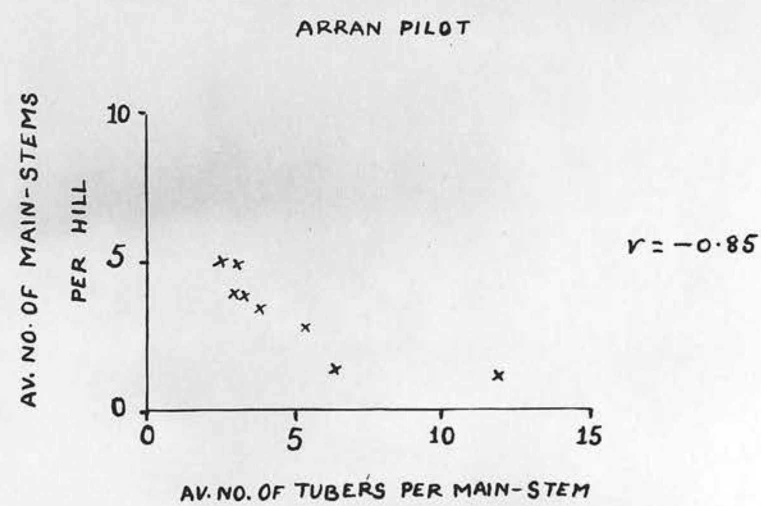
(iii) Above-ground Stems and Tubers

The number of above-ground stems per hill was related to the number of tubers per hill in Arran Pilot ($r = +0.69$) but not in the variety Majestic ($r = +0.02$). The increase in tubers per hill shown in Table 34 proves to be non-significant.

SUB-EXPERIMENT 2, 1959-60

Fig. 7 RELATIONSHIP BETWEEN NUMBER OF MAIN-STEMS PER HILL AND NUMBER OF TUBERS PER MAIN-STEM. (EACH POINT REPRESENTING A TREATMENT MEAN)





(iv) Main-Stems and Tubers per Main-Stem

On the other hand, when the number of main-stems per hill was compared with the number of tubers per main-stem, a negative correlation ($r = -0.85$ and -0.51 for Arran Pilot and Majestic respectively) was obtained. In other words, plants from seed tubers which produced fewer main-stems, gave more tubers per main-stem than other treatments. Chitting which resulted in fewer main-stems, also resulted in a higher tuber: main-stem ratio.

SECTION III

TREATMENT EFFECTS

ON

FINAL YIELDS

1959-60

SECTION III

TREATMENT EFFECTS ON FINAL YIELDS

It has already been said that leaf-roll infected plants were rogued out from the field in order to save the plants of other treatments. No mention will, therefore, be made from now on of those treatments which were sprouted in the glasshouse, i.e. those treatments (Nos. 5, 6, 7, 8 and 14) sprouted in the light, and those (No. 9, 10 and 11) sprouted in the dark (treatment No. 11 was sprouted both in the dark and the light). The effect of low temperature storage, low temperature storage with a short period of heat treatment, and the storage of seed tubers in a pit, will be discussed in detail in this section, with particular emphasis on the different grades of tubers produced. The analysis of variance of the total produce and different grades is presented in the Appendix Table 103.

In order to appreciate the implications of the effects of different storage treatments, an examination of the difference between the treatments (T) and the interaction between treatments and the varieties (TV) is essential. The sum of squares and degrees of freedom (5) for treatments (T) or treatments and varieties (TV) have been further split up into three components to determine the difference between each type of storage. This has been applied for each grade of tuber (except that TV was not split up for the yield and number of chats) and results are included in the same Appendix Table 103.

The interaction of storage treatments with spacing and the three factor interaction with variety and spacing were non-significant throughout the experiment, and the appropriate tables are given in the Appendix Tables 99 and 100 for the yields and numbers with different grades.

Gross Yield of Potatoes

The main effects of the three factors: variety, spacing and storage treatments were not significant for the total yield of tubers, but the effect of spacing, storage treatments, and the interaction of the storage treatment with variety were significant for the total number of tubers.

(i) Effect of Low Temperature Storage and Pit Storage on Yield and Number of Tubers:

Before any further comparison is made between these two types, it should be pointed out again that the seed selected for pit-storage were slightly larger (14.5 per cent by weight) than seed tubers stored at low temperature. The results are therefore likely to have been affected by this difference.

Low temperature storage and pit-storage gave equal yields in Arran Pilot while pit-storage resulted in a 1.5 tons per acre higher yield (non-significant) than low temperature storage in Majestic (Table 35)

TABLE 35

Experiment 1. 1959-60

Effect of Low Temperature Storage and Pit Storage on the Yield and Number of Tubers of Different Grades of Tubers

Yield of Tubers (Tons per Acre)

Storage Condition	Arran Pilot				Majestic				Mean			
	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total
Low Temperature and Heat Treatment	15.5	7.8	0.2	23.5	15.6	6.6	0.3	22.5	15.6	7.2	0.2	23.0
Pit Storage	18.3	5.1	0.1	23.5	18.6	5.2	0.2	24.0	18.4	5.2	0.2	23.8
S.E.	±1.0	±0.5	-	±1.1	±1.0	±0.5	-	±1.1	±0.6	±0.3	-	±0.8

Number of Tubers (Thousands per Acre)

Storage Condition	Arran Pilot Ware	Arran Pilot Seed	Arran Pilot Chats	Arran Pilot Total	Majestic Ware	Majestic Seed	Majestic Chats	Majestic Total	Mean Ware	Mean Seed	Mean Chats	Mean Total
Low Temperature and Heat Treatment	66	102	18	186	74	81	22	177	70	92	19	181
Pit Storage	70	65	8	143	78	70	16	164	74	67	12	153
S.E.	±4.1	±6.6	-	±8.1	±4.1	±6.6	-	±8.1	±2.9	±4.7	-	±5.7

(ii) Effect of a Short Period of Heat Treatment During Low Temperature Storage on Yield and Number of Tubers:

Table 36 shows that low temperature storage for the whole period, or a short period of heat treatment at any time did not significantly differ in the total yields of tubers in either variety. The double heat treatment, however, gave a slight reduction in the yield of tubers in each variety. On the other hand, different storage treatments, as mentioned above, gave significant differences in the total number of tubers produced. Low temperature storage all the time resulted in the greatest number of tubers in the variety Arran Pilot. A short period of heat treatment at any period gave fewer tubers per acre in this variety. There were no marked differences in Majestic as a result of heat treatment.

The results described above agree with the findings of Ehrondorfer (61), who reported an increase in the number of aboveground stems and tubers per hill as a result of storage of seed tubers at 40°F.

TABLE 36

Experiment 1, 1959-60

Effect of Storage Treatment on the Yield and Number of Different Grades of Tubers

Yield of Tubers (Tons per Acre)

Treatment	Arran Pilot				Majestic			
	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total
1. 40°F all through the storage period.	13.7	9.5	0.4	23.6	18.3	5.9	0.2	24.4
2. 40°F all through the storage period except 10 days at 65°- 70°F in November.	15.8	7.8	0.2	23.8	13.5	6.1	0.2	19.8
3. 40°F all through the storage period except 10 days at 65°- 70°F in January.	16.4	7.5	0.2	24.1	15.7	7.2	0.2	23.1
4. 40°F all through the storage period except 10 days at 65°- 70°F in November and January.	16.0	6.4	0.3	22.7	15.0	7.3	0.4	22.7
12. Storage in pit; planted.	18.9	4.2	0.1	23.2	17.2	4.7	0.2	22.1
13. Storage in pit; desprouted before planting.	17.7	6.0	0.2	23.9	20.0	5.7	0.3	26.0
S.E.	±1.0	±0.5	±0.1	±1.3	±1.0	±0.5	±0.1	±1.3

Numbers of Tubers (Thousands per Acre)

Treatment	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total
1. 40°F all through the storage period.	63	136	23	222	84	77	16	177
2. 40°F all through the storage period except 10 days at 65°- 70°F in November.	71	96	19	186	66	81	23	170
3. 40°F all through the storage period except 10 days at 65°- 70°F in January.	67	98	13	179	75	91	22	188
4. 40°F all through the storage period except 10 days at 65°- 70°F in November and January.	64	79	13	156	71	77	25	173
12. Storage in pit; planted.	70	54	6	130	73	64	13	150
13. Storage in pit; desprouted before planting.	69	76	11	156	83	76	18	177
S.E.	±4.7	±7.6	±2.2	±9.4	±4.7	±7.6	±2.2	±9.4

(iii) Effect of Desprouting on Yield and Number of Tubers

Table 36 shows that seed tubers which were stored in the pit for the whole storage period, and desprouted before planting, resulted in a larger number of tubers being produced than undesprouted seed tubers under similar storage conditions, and the difference was significant at the 5 per cent level. The two varieties reacted exactly alike and a difference of 26 and 27 thousand tubers per acre occurred in Arran Pilot and Majestic respectively. But it is interesting to note that the difference (in favour of desprouting) in the yield of Arran Pilot was only 0.7 tons per acre and that in Majestic 3.9 tons per acre, but the differences were not significant. The increase in the number of tubers in favour of the desprouting treatment may be attributed to an increase in the number of above-ground stems as a result of desprouting operation (Table 26).

Figure 8 shows in histographs the yields and number of different grades of tubers as influenced by low temperature storage, heat treatment and storage in the pit as discussed above.

Effect of Variety and Spacing on Yield and Number of Tubers

Table 37 shows that the two varieties gave similar yields and number of tubers per acre.

EXPERIMENT 1, 1959-60

Fig. 8 NUMBER AND WEIGHT OF TUBERS OF DIFFERENT GRADES AS INFLUENCED BY LOW TEMPERATURE STORAGE, HEAT TREATMENT AND STORAGE IN PIT

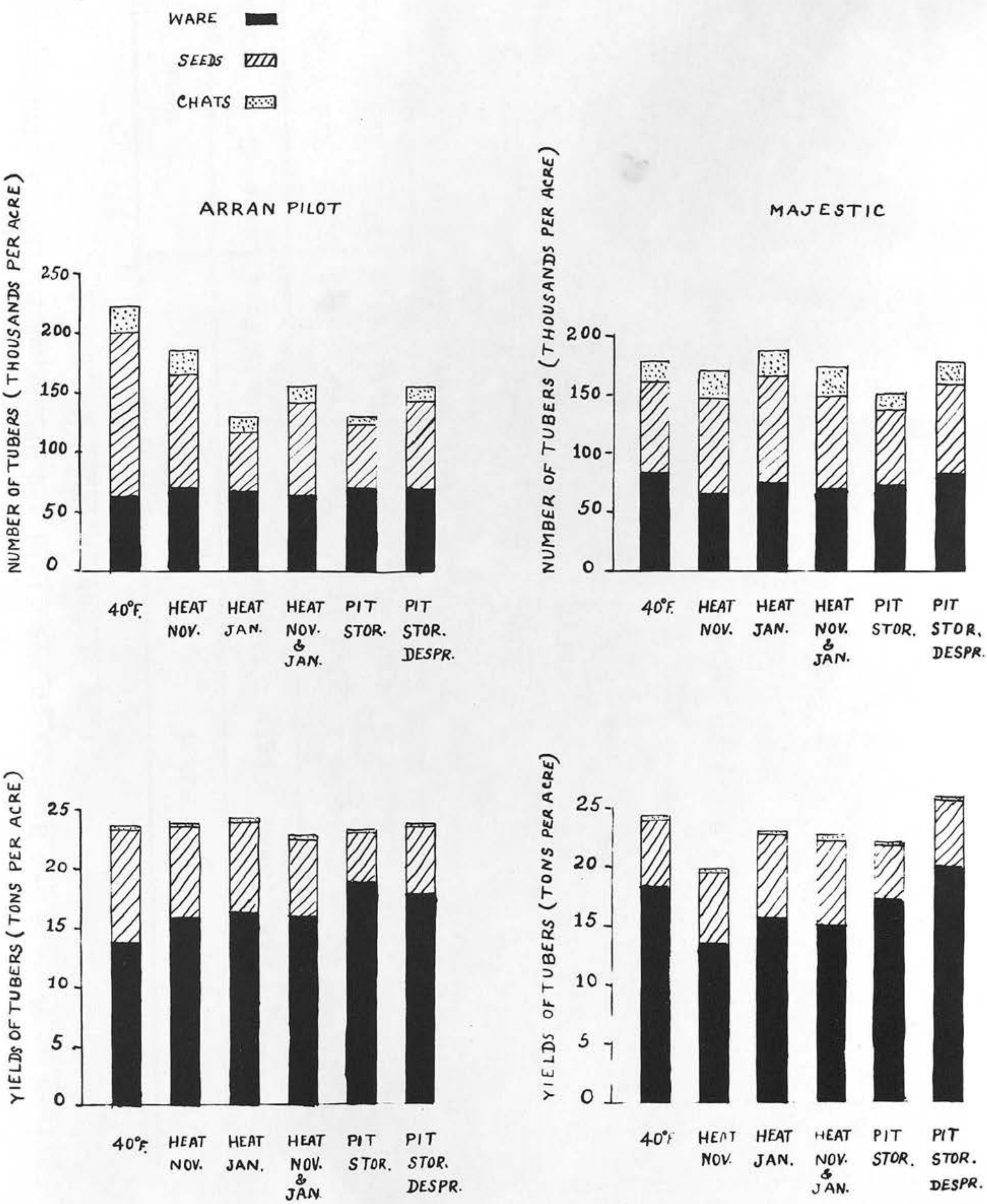


TABLE 37

Experiment 1, 1959-60

Effect of Variety and Spacing on the Yield and Number of Different Grades of Tubers.

Spacing	Arran Pilot				Majestic				Mean			
	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total
	Yield of Tubers (Tons per Acre)											
9"	15.2	8.1	0.2	23.5	16.6	7.6	0.3	24.5	15.9	7.8	0.3	24.0
18"	17.6	5.8	0.1	23.5	16.6	4.7	0.3	21.6	17.1	5.3	0.2	22.6
S.E.	±1.0	±0.6	±0.03	±1.2	±1.0	±0.6	±0.03	±1.2	±0.7	±0.3	±0.02	±0.9
	Number of Tubers (Thousands per Acre)											
9"	68	104	17	189	80	91	22	193	74	97	20	191
18"	66	76	11	153	71	64	17	152	69	70	13	152
S.E.	±3.1	±3.9	±2.6	±6.2	±3.1	±3.9	±2.6	±6.2	±2.2	±2.8	±1.8	±4.4

On the average close spacing (9") out-yielded wide spacing (18") by 1.4 tons per acre, a difference which is below the significance level. But the difference of 39 thousand tubers in favour of close spacing was highly significant. This shows that the average tuber size from wide spacing was much larger than that from close spacing. However, wide spacing increased the yields and number of tubers per hill, due to there being less competition for plant food, and the development of more stolon bearing underground branches. The two varieties gave a similar response except that in Arran Pilot the yields at 9" and 18" were equal, i.e. 23.5 tons per acre.

Although there is some suggestion from Table 37 that Majestic gave a lower yield at the wide spacing, the difference was not significant.

The Yields and Numbers of Different Grades of Tubers

A study of the influence of the different storage treatments on the different grades is necessary from the point of view of the seed potato trade. Since the yield of ware and seed are associated, the following section will deal with these two grades together.

Ware and Seed Grades (Ware: Over $2\frac{1}{4}$" Diameter. Seed: $1\frac{1}{4}$ - $2\frac{1}{4}$ Diameter)

Table 35 shows that on the average, pit storage gave a higher yield and number of ware tubers per acre than low temperature storage and a difference of 2.8 tons per acre was highly significant, while a difference of 4 thousand ware tubers per acre was not significant. This shows that the average size of ware was large enough to give a significant difference in the quantity. The two varieties gave a similar response.

An opposite reaction was noted in the yield of seed tubers. Pit-storage gave a significantly lower yield of seed tubers, and low temperature storage out-yielded pit-storage by 2.0 tons per acre or 25 thousand seed tubers per acre, the differences in both yields and numbers being highly significant. The difference in the number of seed tubers was more marked in Arran Pilot than in Majestic, which resulted in the interaction of storage treatments with variety being significant at the 5 per cent level.

Pit-Storage, as already discussed in the growth analysis section, on the average, developed fewer above-ground stems per seed tuber than seed tubers stored at low temperature. This in turn gave higher proportion of ware tubers. Low temperature storage, on the other hand, resulted in more above-ground stems and more seed tubers.

(ii) Effect of a Short Period of Heat Treatment During Low Temperature Storage on the Yield and Number of Ware and Seed Tubers

The two varieties responded differently. Table 36 shows that a low temperature for the whole storage period resulted in the lowest yield and number of ware in Arran Pilot, whereas it gave the greatest yield and number in Majestic. A short period of heat treatment increased the yield and number of ware tubers in Arran Pilot whereas it decreased them in Majestic. The differences in the yield of ware as a result of the different treatments were greater in Majestic than in Arran Pilot, and the difference in the yield of ware of Majestic between no heat treatment and heat treatment in November was significant at the 5 per cent level.

On the other hand, low temperature storage for the whole period resulted in the greatest yield and number of seed tubers in Arran Pilot whereas it gave the lowest yield and number in Majestic. A short period of heat treatment at any period reduced the yield and number of seed tubers in Arran Pilot whereas it increased them in Majestic. The increase or decrease in the yield or number of seed tubers was related to the time and amount of heat treatment given to the seed tubers. Thus, in Arran Pilot, the double heat treatment (November and January) gave a lower yield and number of seed tubers than single dose of heat treatment in November or January. In Majestic, however, the response to heat treatment was the opposite, that is to say, there was a suggestion of an increase in the number of seed tubers (but a decrease of ware tubers) with an increase in the amount of heat treatment. The interaction of storage treatments with variety for the yields and the number of ware and seed tubers was thus highly significant.

The yield and number of seed-sized tubers produced is governed by the total number of tubers produced per hill. Any treatment, which results in more tubers per hill, also results in more seed tubers per hill, because of their restriction in size. Arran Pilot gave the greatest number of above-ground stems per hill

(Table 10) at low temperature storage for the whole period and also gave the largest number of tubers per hill, resulting in a high proportion of seed tubers.

Effect of Variety and Spacing on the Yield and Number of Ware and Seed Tubers

Table 37 shows that wide spacing, on the average, gave an increase of 1.2 tons per acre of ware, but a decrease of 5 thousand ware tubers per acre, showing that the average size of ware at the wide spacing was larger than that of close spacing. The interaction of variety with spacing was not significant.

The same Table, i.e. 37, also includes the data for seed-sized tubers, where the opposite situation was found. On the average close spacing gave higher yields and numbers of seed tubers per acre, and the differences were highly significant. Arran Pilot gave higher yields and numbers of tubers at both spacings than Majestic. The interaction of variety with spacing was not significant.

Effect of Storage Treatments on the Yield and Number of Chats

Chats are not generally part of the saleable crop (but with valuable seed are often planted). Since the total yield and number of tubers included the contribution of chats also, a brief mention will be made of the reasons for an increase or decrease in the yield and number of chats as a result of certain storage treatments. Tables 35 to 37 reveal that usually any treatment which resulted in a higher yield or number of tubers also gave a higher yield and number of seed tubers, and in turn, a higher yield and number of chats. Table 35 shows that low temperature storage gave a greater yield and number of chats in both varieties than the pit-storage treatment (desprouted and undesprouted). Also a short period of heat treatment at any time reduced the yield and number of chats in Arran Pilot whereas it increased them in Majestic. Desprouting the seed tubers before plantinging resulted in a higher yield and number of chats than from the undesprouted treatment, the difference in the yield being significant at the 5 per cent level.

SECTION I

STORAGE PERIOD

1960-61

SECTION I

STORAGE PERIOD

EXPERIMENTAL METHODS AND MATERIALS, 1960-61

In 1960-61 the same two varieties, Arran Pilot and Majestic were used in the experiment. The seed potatoes were stored in cardboard boxes, 18"x9"x9", which were light proof. This time, two seed sizes (large = 120-140 g. and small = 80-100 g. per set) were used in the experiment. Also, most of the treatments, such as a short heat treatment during low temperature storage at different intervals, and sprouting seed tubers in dark, and storage in pit were not included in the study. It was decided to concentrate the effort on fewer factors. Other changes made were to sprout the seed tubers more frequently than in the previous crop to control the number of sprouts per seed tuber.

110 seed tubers of each variety and size were stored in 40 boxes. Two boxes of each variety and size were transferred in November to sprouting trays (30" x 18" x 3") and placed in a laboratory for sprouting. Half of the remaining boxes of potatoes were stored in a low temperature room (40°F), and half were treated with TCNB at the rate of 10 lb. per ton and stored in a frost proof barn at Boghall Farm.

Tubers were taken out from the low temperature storage and the barn at Boghall at regular intervals of one month (i.e. December, January and February) and set up for sprouting in the laboratory. One lot of each variety and size was not set up for sprouting.

TCNB treated seed tubers were cleaned with a cloth when removed from the boxes for sprouting. A sample of 10 seed tubers of each treatment was studied for sprouting behaviour, and changes in dry matter content, and loss of weight during the storage period for the Experiment 1, while only 5 seed tubers were studied in Experiment 2 (no dry matter changes studied due to shortage of seed tubers).

To evaluate a relationship between number of sprouts per seed tuber and the length of the sprouts on the development and yield, a separate experiment (No. 2) was conducted on a small scale, with the same two varieties. Five dates of chitting (i.e. November, December, January, February and unsprouted) and three sprout length levels (i.e. L_1 = longest sprouts approx. 1 cm, L_2 = approx. 2 cm. and L_3 = approx. 3 cm.) were considered in the experiment. Twenty-five seed tubers were sprouted in small trays (15" x 10" x 3") on the same dates as those adopted for Experiment 1.

Scottish Seed "A" Certificate of both varieties were used. The sizing was done by hand. Arran Pilot on the average weighed slightly (5-10 g. per set) less than Majestic.

EXPERIMENTAL RESULTS

Sprouting of Seed Tubers as Influenced by Environmental Conditions of the Storage

Before describing the results of the experiments for this season, it is essential to discuss first the environmental conditions under which the sprouting seed tubers remained. It has already been pointed out in the Literature Review that light and temperature play a most vital role in the sprouting behaviour of seed tubers. Variation in either of these two factors can affect the sprouting situation of the seed tubers. The present work was influenced by weather changes. The room in the School of Agriculture used for sprouting recorded a daily minimum temperature of 42-56° F. and a daily maximum temperature of 60-68°F. from November 1960 to 3rd. March, 1961. It was decided that the sprouting tubers should be transferred to the cool condition in the barn at Boghall when the sprouts had reached a satisfactory size. Sprouting tubers of Arran Pilot which were transferred to the barn by February became etiolated due to absence of enough light and grew to 6-9 cm. in length in a week. Arrangements were made immediately to provide artificial light in the barn with four fluorescent lights (5 ft. long) from 4th. March onwards. The position of each tray was changed twice a week to give all the treatments an equal amount of light. From that period on, the sprout-length was considerably checked, and the etiolated parts of the sprouts turned green, and by planting time, the sprouts were vigorous and tough.

TABLE 38

Temperature Record During Storage Period, 1960-61

Laboratory 1			Barn at Boghall			Laboratory 2		
Period	Min °F	Max °F	Period	Min °F	Max °F	Period	Min °F	Max °F
4 Nov - 11 Nov	52	64	4 Nov - 11 Nov	41	44			
11 Nov - 18 Nov	56	66	11 Nov - 18 Nov	41	42			
18 Nov - 25 Nov	52	65	18 Nov - 25 Nov	42	45			
25 Nov - 2 Dec	56	68	25 Nov - 2 Dec	43	48			
2 Dec - 9 Dec	50	66	2 Dec - 9 Dec	39	41			
9 Dec - 16 Dec	50	60	9 Dec - 16 Dec	36	38			
16 Dec - 23 Dec	51	62	16 Dec - 22 Dec	36	39			
23 Dec - 30 Dec	50	66	22 Dec - 30 Dec	37	39			
30 Dec - 6 Jan	50	60	30 Dec - 4 Jan	38	40			
6 Jan - 13 Jan	47	63	4 Jan - 14 Jan	35	42			
13 Jan - 20 Jan	44	60	14 Jan - 21 Jan	35	41			
20 Jan - 27 Jan	44	59	21 Jan - 30 Jan	35	40			
27 Jan - 3 Feb	46	60	30 Jan - 3 Feb	36	40			
3 Feb - 10 Feb	45	64	3 Feb - 10 Feb	36	44			
10 Feb - 17 Feb	49	62	10 Feb - 17 Feb	41	46			
17 Feb - 24 Feb	44	61	17 Feb - 24 Feb	41	45			
24 Feb - 3 Mar	42	60	24 Feb - 3 Mar	46	53			
			3 Mar - 10 Mar	45	52			
3 Mar - 10 Mar	48	66	10 Mar - 17 Mar	46	52	10 Mar - 17 Mar	56	60
			17 Mar - 24 Mar	40	54	17 Mar - 24 Mar	50	59
			24 Mar - 31 Mar	40	50	24 Mar - 31 Mar	48	58
			31 Mar - 7 Apr	38	47	31 Mar - 7 Apr	50	54
			7 Apr - 14 Apr	40	52	7 Apr - 14 Apr	53	65
			14 Apr - 21 Apr	46	53	14 Apr - 21 Apr	56	63
			21 Apr - 28 Apr	46	52			

TABLE 39

Experiment 1, 1960- 61

Period Under Which Chitting Seed Tubers Remained in Different Environmental Conditions

Dates of Chitting	Arran Pilot				Majestic			
	Lab. 1	Days	Boghall Barn	Days	Lab 1	Days	Boghall Barn	Days
			Till				Till	
November	4 Nov-13 Dec	39	13 Dec-Planting	135	4 Nov-3 Mar	119	3 Mar-Planting	55
December	2 Dec-9 Jan	38	9 Jan- "	109	2 Dec- "	91	"	55
January	4 Jan-8 Feb	35	8 Feb- "	78	4 Jan- "	58	"	55
February	9 Feb-3 Mar	22	3 Mar- "	55	9 Feb- "	22	"	55

TABLE 40

Experiment 2, 1960-61

Dates of Chitting	Sprout Length Levels	Arran Pilot Lab. 1	Days	Lab.2	Days	Boghall Barn	Days	Majestic Lab.1	Days	Lab.2	Days	Boghall Barn	Days
November	L_1	4 Nov- 7 Dec	33	-		7 Dec- Till Planting	143	4 Nov- 3 Mar	119	-		3 Mar- Till Planting	57
	L_2	4 Nov- 3 Jan	60	-		3 Jan-"	116	4 Nov- 8 Mar	124	8 Mar- 16 Mar	8	16 Mar-"	44
	L_3	4 Nov- 31 Jan	88	-		31 Jan-"	88	4 Nov- 8 Mar	124	8 Mar- 30 Mar	22	30 Mar-"	30
December	L_1	2 Dec- 9 Jan	38	-		9 Jan- "	120	2 Dec- 3 Mar	91	-		3 Mar-"	31
	L_2	2 Dec- 31 Jan	60	-		31 Jan-"	88	2 Dec- 8 Mar	96	8 Mar- 23 Mar	15	23 Mar-"	37
	L_3	2 Dec- 13 Feb	73	-		13 Feb-"	75	2 Dec- 8 Mar	96	8 Mar- 23 Mar	15	23 Mar-"	37
January	L_1	4 Jan- 8 Feb	35	-		8 Feb- "	80	4 Jan- 3 Mar	58	-		3 Mar-"	58
	L_2	4 Jan- 3 Mar	58	-		3 Mar- "	55	4 Jan- 8 Mar	63	8 Mar- 30 Mar	22	30 Mar-"	30
	L_3	4 Jan- 8 Mar	63	8 Mar- 16 Mar	8	16 Mar-"	44	4 Jan- 8 Mar	63	8 Mar- 30 Mar	22	30 Mar-"	30
February	L_1	9 Feb- 3 Mar	22	-		3 Mar-"	55	9 Feb- 8 Mar	27	8 Mar- 23 Mar	15	23 Mar-"	37
	L_2	9 Feb- 8 Mar	27	8 Mar- 20 Mar	12	20 Mar-"	40	9 Feb- 8 Mar	27	8 Mar- 23 Mar	15	23 Mar-"	37
	L_3	9 Feb- 8 Mar	27	8 Mar- 30 Mar	22	30 Mar-"	30	9 Feb- 8 Mar	27	8 Mar- 24 Mar	16	24 Mar-"	38

All the sprouting tubers of Experiment 1 were stored in the barn at Boghall, while most of the sprouting tubers of Experiment 2 were transferred to another laboratory for 1-3 weeks commencing March 9th. where the temperature ranged from 48° to 60°F. The light and temperature conditions of this laboratory were similar to those of the first laboratory. A temperature record and the period under which the tubers of each experiment were sprouted in these environments are given in Tables 38 to 40.

EXPERIMENT 1

The Effects of Various Methods of Storing and Sprouting Seed Tubers on the Subsequent Yield of Ware and Seed

Effect of Storage Treatment on the Development of Sprouts

Table 41 shows that continuous low temperature storage (40°F) or the application of TCNB all through storage ($37-54^{\circ}$F) kept the seed tubers dormant for a considerable period, and no visible sprouts were noticed till December in Arran Pilot, and February in Majestic under low temperature storage, and January for Arran Pilot and April for Majestic under TCNB application. In each variety, the large seed tubers sprouted 5-10 days earlier than the smaller ones.

TABLE 41

Experiment 1, 1960-61

Distribution of Sprouts per Seed Tuber of Various Size (cm.) Group on 19.4.1961

Dates of Chitting	Arran Pilot					Majestic			
	+	0-1	1-4	4-10	Total	+	0-1	1-3	Total
November	0.8	6.6	2.1	1.2	10.7	0.9	2.4	1.1	4.4
December	0.9	8.6	0.5	2.2	12.2	1.2	3.2	1.2	5.6
January	0.6	9.6	0.7	2.0	12.9	1.9	7.2	1.5	10.6
February	0.3	11.5	2.4	0.6	14.8	1.0	10.5	2.1	13.6
No Chitting	0.4	5.4	0.1	-	5.9	Visible Sprouts			

Arran Pilot set up for chitting on 4th. November started to sprout about a fortnight later, and in one month the longest sprout was 1-2 cm. long. Two to three dominant sprouts per seed tuber, usually on the apical region, were noticed in the large and small seed tubers. There were short sprouts below 1.o cm. which remained suppressed until April. Majestic, on the other hand developed a single dominant sprout on the apical region from the beginning of the sprouting period, clearly showing the existence of apical dominance. Other sprouts numbering not more than 5-10 were in the visible sprouting phase, and did not show any marked growth.

Arran Pilot, chitted from 2nd. December, showed multiple sprouting within 10 days, but like the November chitting, 2-3 dominant sprouts were noted from February onwards. Majestic developed sprouts of only 0.2-0.5 cm. in one month of chitting and of 1.0-1.5 cm. in three months (i.e. by 3rd. March). The number of dominant sprouts was only one (or two in some tubers) per seed tuber.

Arran Pilot, chitted from 4th. January, developed sprouts of 1.0-2.5 cm. in one month of chitting. In two months, the sprouts did not grow more than 1.5-3.0 cm. The number of dominant sprouts (usually from the apical region) per seed tuber here also was 2-3, while others, smaller than 0.5 cm., were growing very slowly.

Arran Pilot, chitted from 9th. February, gave multiple sprouting and after a month some of the longest sprouts were developing from the middle region. However, after they were transferred to the barn at Boghall the dominant sprouts grew much faster at the apical region than the middle region. Majestic also showed multiple sprouting for about one month only. Thereafter it was noted that there were one to two dominant sprouts, usually at the apical region.

It was intended that sprouts of no more than 1-2 cm. should be produced by the seed tubers. On attaining this length tubers were transferred to cooler conditions in the barn to await planting time in order that further growth should be small. Arran Pilot tubers chitted from November, December, January and February required respectively 39, 38, 35, and 22 days to reach the required size. In Majestic all the sprouts reached the length of 1-2 cm. together on 4th. March when they were transferred. The period stored in each environmental condition is shown in Table 39.

The number of sprouts per seed tuber and the average length of the longest sprout were recorded in the middle of April, before planting on 28th. and 29th. April, 1961 and are given in Tables 41 and 42 respectively.

TABLE 42

Experiment 1, 1960-61

Average Length (cm.) of the Longest Sprouts* per Seed Tuber on 19.4.1961

Dates of Chitting	Arran Pilot Low Temp.	Arran Pilot TCNB	Arran Pilot Av.	Majestic Low Temp.	Majestic TCNB	Majestic AV.
November	5.2	5.3	5.2	2.4	2.3	2.3
December	6.7	9.4	8.0	2.4	2.1	2.2
January	6.8	9.0	7.9	2.0	2.0	2.0
February	3.5	4.1	3.8	1.2	2.1	1.6
No Chitting	0.8	+	-	+	+	-

* Average of 10 Seed Tubers.

Table 41 shows that the number of sprouts per seed tuber increased as the date of chitting advanced in both the varieties. Low temperature storage followed by chitting gave slightly more sprouts per seed tuber than TCNB treated seed tubers in Arran Pilot, while with Majestic the differences were negligible. Although the number of sprouts per seed tuber increased at successive dates of chitting, there was not much difference in the number of dominant sprouts per seed tuber. For each sprouting date there was an average of 2-3 dominant sprouts (sprouts between 1-10 cm) in Arran Pilot, while in Majestic there were 1-2 dominant sprouts per seed tuber (1-3 cm). The influences of the two methods of storage (i.e. low temperature storage and TCNB application), two seed sizes and dates of chitting on the development of sprouts per seed tuber are showin in Table 104 in the Appendix. It should be noted here, however, that tubers chitted for a longer period always developed more nodes than others with a shorter period (Table 43). For example, seed tubers of Arran Pilot developed 10.2 nodes per dominant sprout when they were set up for sprouting in November, while there were only 8.3 nodes per dominant sprout when chitted from February. The respective figures for Majestic were 13.6 and 9.4.

TABLE 43

Experiment 1. 1960-61

Average Number of Nodes per Dominant Sprout on 19.4.1961

Dates of Chitting	Arran Pilot	Majestic
November	10.2	13.6
December	9.6	13.4
January	9.9	12.9
February	8.3	9.4
No Chitting	-	-
Mean	9.5	12.2

Under TCNB treatment for the whole storage period, the sprouts of Arran Pilot became visible in the middle of February and in Majestic the sprouts became visible in the middle of April. Seed tubers of Arran Pilot stored at low temperature gave visible sprouts sometime in January and grew to about 0.5-1.0 cm. by the end of April. In Majestic sprouts were visible in February and were 1-2 mm. in some tubers by the end of April.

Table 42 gives the average length of the longest sprout per seed tuber before planting. There was a trend for a reduction in the length of sprouts as the chitting became later in Majestic, but in Arran Pilot, there was no such trend, and chitting from November gave shorter sprouts than chitting from December and January which was presumably due to etiolation of sprouts in the barn.

Development of Sprouts and Main-stems from Different Regions of the Seed Tubers

Table 44 shows that most of the sprouts developed from the apical region of the seed tubers, irrespective of the date of chitting and methods of storage in each variety. The proportion of sprouts increased on the middle region as the date of chitting advanced. The main-stems (i.e. the dominant sprouts emerging above-ground) generally developed from the apical region, but a very few developed from the middle region, and a very occasional one from the heel region. Unsprouted tubers from low temperature storage or TCNB application on the other hand developed a few more sprouts or main-stems from the middle region. This shows that seed tubers, when stored for a considerable period at low temperature or under treatment with TCNB, show a reduction in apical dominance.

Loss of Fresh Weight (%) of Potato Seed Tubers during the Chitting Period

Ten seed tubers were marked and weighed at the time of chitting the seed tubers. After chitting they were weighed again in order to assess the percentage of loss of weight due to shrinkage[1].

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1 Shrinkage: Losses due to transpiration, respiration and sprouting.

TABLE 44

Experiment 1, 1960-61

Average Number of Sprouts[1] and Main-stems[2] Developing from Different Regions of the Seed Tubers

Dates of Chitting	Sprouts and Main-Stems	Arran Pilot								Majestic							
		Low Temp. Storage				TCNB Application				Low Temp. Storage				TCNB Application			
		A.R.	M.R.	H.R.	Tot.	A.R.	M.R.	H.R.	Tot.	A.R.	M.R.	H.R.	Tot.	A.R.	M.R.	H.R.	Tot.
Nov.	Sprouts	8.5	2.4	0.4	11.3	6.7	3.2	0.3	10.2	3.5	0.6	0.2	4.3	3.7	0.8	0.1	4.6
	Main-Stems	2.8	0.2	-	3.0	2.7	0.2	-	2.9	1.1	-	-	1.1	1.5	-	-	1.5
Dec.	Sprouts	7.8	5.2	0.3	13.3	7.8	3.2	0.1	11.1	4.6	1.3	0.4	6.3	4.8	0.2	-	5.0
	Main-Stems	2.5	0.2	-	2.7	2.4	0.1	-	2.5	1.3	-	-	1.3	1.5	-	-	1.5
Jan.	Sprouts	7.8	5.8	0.6	14.2	6.3	4.9	0.4	11.6	6.3	3.7	0.5	10.5	6.6	3.6	0.5	10.7
	Main-Stems	2.6	0.2	-	2.8	2.0	0.5	-	2.5	1.3	0.2	0.1	1.6	1.5	-	-	1.5
Feb.	Sprouts	8.6	6.1	0.2	14.9	7.6	6.3	0.8	14.7	6.2	5.5	1.4	13.1	7.2	5.8	1.1	14.1
	Main-Stems	3.0	-	-	3.0	2.1	0.6	0.2	2.9	1.7	0.2	-	1.9	2.2	-	-	2.2
No Chitting	Sprouts	7.3	4.0	0.5	11.8	+	+	+	+	+	+	+	+	+	+	+	+
	Main-Stems	5.0	3.6	-	8.6	3.5	1.7	0.2	5.4	3.6	0.5	0.1	4.2	2.9	0.7	0.1	3.7

[1]Sprouts: Average of 20 Seed Tubers

[2]Main-Stems: Average of 24 Seed Tubers (See Table 112)

A.R. Apical Region

M.R. Middle Region

H.R. Heel Region

Table 45 shows that on the average seed tubers chitted for a longer period lost more weight than those chitted for a shorter period, except that chitting from December resulted in slightly greater loss of fresh weight than those chitted from November in Arran Pilot, and chitting from February gave more loss of weight than those chitted from January in Majestic. Unsprouted seed tubers, on the other hand, lost approximately 50 per cent less fresh weight than sprouted tubers.

TABLE 45

Experiment 1, 1960-61

Loss of Fresh Weight (%) of Potato Seed Tubers During Chitting Period

Dates of Chitting	Arran Pilot	Majestic
November	11.0	11.6
December	11.2	8.5
January	10.5	6.9
February	8.0	8.1
No Chitting	5.9	5.1

The influence of methods of storage, seed sizes and different dates of chitting on the loss of fresh weight is given in Table 105, and the average effects of the former two factors are summarised in Tables 106 and 107 respectively, in the Appendix. Table 106 shows that, on the average, low temperature storage and TCNB application resulted in a loss of fresh weight of 8.9 per cent and 9.2 per cent respectively in Arran Pilot while 8.6 per cent and 7.5 per cent in Majestic, the differences being marginal.

Table 107 shows that, on the average, large and small seed tubers resulted in a loss of fresh weight of 9.0 per cent and 9.1 per cent respectively in Arran Pilot, while 8.0 per cent and 8.1 per cent in Majestic, the differences being marginal.

Dry Matter Changes in the Seed Tuber Before and After Chitting

A sample of 5 seed tubers was taken at the time of sprouting for each date, and the dry matter content was determined. Another sample of seed tubers was taken before planting from each treatment and the dry matter content was determined. Table 46 shows that the dry matter percentage of the unsprouted seed tubers increased at successive dates of sampling in both the varieties.

TABLE 46

Experiment 1, 1960-61

Dry Matter (%) in Potato Seed Tubers Before and After Chitting

	Arran Pilot		Majestic	
Dates of Chitting	At the time of Chitting	19.4.1961.	At the time of Chitting	19.4.1961
November	15.9	17.7	16.0	18.1
December	16.5	18.9	16.3	17.8
January	16.9	19.2	17.1	17.2
February	17.1	18.4	17.1	17.5
No Chitting	-	17.2	-	17.3

For the dry matter contents at planting time, there was a suggestion that the later the chitting started the higher was the dry matter content in Arran Pilot. On the other hand, the trend was the opposite in Majestic.

The influences of the two methods of storage (i.e. low temperature storage and TCNB application), two seed sizes, and dates of chitting on the dry matter changes, are shown in Tables 108 to 110 in the Appendix. The effects were negligible.

EXPERIMENT 2

The Effects of Sprout Number and Sprout Length on the Subsequent Yield of Ware and Seed

Effect of Storage Treatments on the Development of Sprouts

The development of sprouts during the chitting period was similar to the sprouting behaviour of seed tubers of Experiment 1, as the tubers of each experiment were chitted on the same dates. The growth of sprouts at different dates will therefore not be discussed here. However, details require to be given of how the chitting seed tubers were moved from one environment to the other in order to control the length of the sprout.

Seed tubers of three sprout length levels (L_1, L_2, and L_3) of Arran Pilot chitted from November were transferred from laboratory 1 to the barn at Boghall after 33, 60 and 88 days respectively when the sprouts grew to the desired size, i.e. approximately, 1.0, 2.0 and 3.0 cm. respectively. Similarly, seed tubers chitted from December were transferred to the barn after 38, 60 and 73 days of chitting in laboratory 1, when they developed sprouts of the desired length. Tubers chitted from January were transferred there after 35, 58 and 65 days respectively.

Majestic seed tubers, on the other hand, gave a very slow rate of sprout growth during the chitting period. For practical reasons of convenience all the sprouting tubers were moved to laboratory 2 (similar to laboratory 1) at the beginning of March where they were kept for 7-21 days; thereafter they were finally moved to the barn at the dates shown in Table 40 for sprouting under artificial light until planting. It should be mentioned here that Majestic seed tubers of two sprout length levels, namely, L_2 and L_3 which were chitted from December, January and February were treated similarly and so they were not different from each other. Likewise, L_1 and L_2 chitted from February were alike. Comparisons between L_2 and L_3 are therefore likely to be of little value for this variety.

The final number of sprouts per seed tuber and the average length of the longest sprout are given in Tables 47 and 48 respectively. The data were recorded on 13th. April, 1961.

TABLE 47

Experiment 2, 1960-61

Distribution of Sprouts[1] per Seed Tuber of Various Size (cm) Group on 13.4.1961 as Influenced by Sprout Length and Chitting

Arran Pilot

Dates Of Chitting	L_1					L_2					L_3					Av. No. $L_1 - L_3$
	+	0-1	1-4	4-12	Tot.	+	0-1	1-4	4-12	Tot.	+	0-1	1-4	4-12	Tot.	
November	0.8	8.4	1.2	1.2	11.6	0.2	7.4	-	1.6	9.2	2.2	3.6	2.0	1.4	9.2	10.0
December	1.8	8.4	1.0	2.2	13.4	3.2	8.8	1.4	1.4	14.8	0.8	6.4	0.8	1.6	9.6	12.6
January	1.2	11.2	2.4	0.6	15.4	0.2	12.2	1.2	1.0	14.6	0.8	10.2	2.2	0.6	13.8	14.6
February	-	11.8	2.6	1.0	15.4	0.8	10.6	2.0	0.6	14.0	0.2	11.0	2.6	0.8	14.6	14.7
No Chitting	3.6	13.0	-	-	16.6	4.8	9.2	-	-	14.0	6.0	7.2	-	-	13.2	14.6
Mean					14.5					13.3					12.1	
Majestic																
November	0.6	3.0	1.0	0.2	4.8	0.8	1.8	1.4	-	4.0	0.8	5.6	1.4	0.2	8.0	5.6
December	0.6	6.0	0.2	0.8	7.6	2.0	2.4	1.6	-	6.0	2.6	4.4	0.6	0.6	8.2	7.3
January	2.0	6.6	1.2	0.8	10.6	1.6	9.8	1.6	-	13.0	2.2	9.4	1.0	0.4	13.0	12.2
February	1.4	10.8	0.6	-	12.8	2.0	9.6	2.0	-	13.6	1.2	7.6	1.8	-	10.6	12.3
No Chitting					Visible						Sprouts					
Mean					8.9					9.1					9.5	

[1]Average of 5 Seed Tubers

Table 47 shows that the number of sprouts per seed tuber increased steadily as the date of setting up for chitting became later in both varieties. Unsprouted seed tubers of Arran Pilot gave the largest number of sprouts per seed tuber. This variety gave more sprouts per tuber than Majestic at all dates of chitting.

There was an interaction between variety and sprout length levels. As the sprout length increased the number of sprouts per seed tuber decreased in Arran Pilot, while in Majestic there was an increase in the number of sprouts. The reduction in the number of sprouts in Arran Pilot, with the longer sprout treatment, was due to the fact that some of the sprouts, usually below 0.5 cm. in length, died off when the tubers were left for a longer period at 48-66°F. to increase the sprout length. The increase in sprout number in Majestic with the longer chitting period, however, suggests that this variety needs a longer period to sprout under the same storage conditions.

TABLE 48

Experiment 2, 1960-61

Average Length (cm) of the Longest Sprout[1] per Seed Tuber on 13.4.1961.

Dates of Chitting	Arran Pilot L_1	L_2	L_3	Mean	Majestic L_1	L_2	L_3	Mean
November	7.9	10.1	12.0	10.0	2.4	2.5	2.8	2.6
December	9.2	10.5	9.9	9.9	2.4	2.3	3.0	2.6
January	3.7	8.0	4.9	5.5	2.4	2.2	3.0	2.5
February	5.1	4.3	5.3	4.9	1.2	1.9	1.7	1.6
No Chitting	0.6	0.4	0.4	0.5	+	+	+	+
Mean	5.3	6.6	6.5		2.4	2.2	2.5	

[1]Average of 5 Seed Tubers

Although the number of sprouts per seed tuber increased at successive date of chitting, there was a much smaller difference in the number of dominant sprouts (sprouts developing to main-stems) per seed tuber, and an average of 2-3 dominant sprouts (sprouts between 1-12 cm. range, Table 47) occurred in Arran Pilot and 1-2 sprouts per tuber (1-3 cm) were present in Majestic. There was, however, still a consistent trend for the number of such dominant sprouts to increase with later dates of chitting in both varieties.

Tubers chitted for a longer period always developed more nodes than those chitted for a shorter time. As many as 7-10 nodes per dominant sprout were noted in tubers chitted from November in Arran Pilot, and 9-11 nodes in Majestic (Table 49).

TABLE 49

Experiment 2, 1960-61

Average Number of Nodes per Dominant Sprout (13.4.1961.)

Dates of Chitting	Arran Pilot				Majestic			
	L_1	L_2	L_3	Av.	L_1	L_2	L_3	Av.
November	10	8	8	8.6	11	10	9	10.0
December	8	8	6	7.3	13	12	9	11.3
January	7	8	7	7.3	13	14	10	12.3
February	8	7	8	7.6	12	11	8	10.3
No Chitting	-	-	-	-	-	-	-	-
	8.3	7.7	7.2	7.7	12.2	11.7	12.0	10.9

On the average, the short sprout length level (L_1) e.g. the one kept in the cool barn for the longest period, gave slightly more nodes per dominant sprout than those of L_2 and L_3. This increase in the number of nodes could possibly allow a greater number of tubers to be formed per main-stem (discussed in Section III).

Development of Sprouts from Different Regions of the Seed Tuber

The nature of sprouting from different regions of the seed tubers was similar to that in Experiment 1 and the results are given in Table 50.

% Loss of Fresh Weight of Potato Seed Tubers during the Chitting Period

Five seed tubers were marked and weighed at the time of chitting at different dates. After chitting the final weight was taken to determine the percentage of loss of weight due to shrinkage. Table 51 shows that, on the average, seed tubers chitted for a longer period lost more weight than those subjected to a short period of chitting in each variety. Unsprouted tubers lost the least weight.

On the average the tubers under the short sprout treatment lost less weight than those on medium and long sprout treatments in Majestic, presumably because it was kept at low temperature for chitting in the barn for a longer period than the latter. In Arran Pilot, however, variable results were obtained.

TABLE 50

Experiment 2, 1960-61

Development of Sprouts from Different Regions of the Seed Tubers on 19.4.1961

Arran Pilot

Dates of	L_1				L_2				L_3			
Chitting	A.R.	M.R.	H.R.	Tot.	A.R.	M.R.	H.R.	Tot.	A.R.	M.R.	H.R.	Tot.
1. November	7.2	4.0	0.4	11.6	5.6	3.6	-	9.2	7.0	2.2	-	9.2
2. December	9.8	3.4	0.2	13.4	9.4	5.2	0.2	14.8	5.8	3.2	0.6	9.6
3. January	8.6	6.4	0.4	15.4	8.4	5.4	0.8	14.6	8.6	4.6	0.6	13.8
4. February	7.0	7.8	0.6	15.4	8.0	5.4	0.6	14.0	8.0	5.4	1.2	14.6
5. No Chitting	8.0	7.6	1.0	16.6	7.8	5.8	0.4	14.0	7.8	5.0	0.4	13.2

Majestic

1. November	4.2	0.6	-	4.8	3.0	0.4	0.6	4.0	5.2	2.2	0.6	8.0
2. December	6.0	1.2	0.4	7.6	5.2	0.8	-	6.0	5.6	2.0	0.6	8.2
3. January	6.0	4.0	0.6	10.6	8.0	4.2	0.8	13.0	8.4	4.4	1.2	13.0
4. February	7.4	4.8	0.6	12.8	6.2	6.0	1.4	13.6	7.0	2.6	1.0	10.6
5. No Chitting		+				+				+		

TABLE 51

Experiment 2, 1960-61

Loss of Fresh Weight (%) of Potato Seed Tubers During Chitting

Dates of Chitting	Arran Pilot				Majestic			
	L_1	L_2	L_3	Mean	L_1	L_2	L_3	Mean
November	10.0	13.3	11.5	11.6	12.2	12.2	14.4	12.9
December	10.8	11.3	10.4	10.8	7.3	8.8	11.4	9.2
January	9.6	10.6	6.6	8.9	7.3	8.8	11.1	9.1
February	5.2	7.8	6.3	6.4	6.1	8.9	8.3	7.8
No Chitting	4.2	4.2	4.2	4.2	3.7	3.7	3.7	3.7
Mean	7.9	9.4	7.8		7.3	8.1	9.8	

SECTION II

EFFECT OF STORAGE ON THE SUBSEQUENT DEVELOPMENT OF THE PLANT IN THE FIELD

1960-61

EFFECT OF STORAGE ON THE SUBSEQUENT DEVELOPMENT OF THE PLANT IN THE FIELD

EXPERIMENTAL METHODS AND MATERIALS

The two main experiments (i.e. Experiment 1 and Experiment 2) were conducted at the same area of land on Boghall Farm. The nature of the soil was similar to that in the experiments of 1960, and the description is given in Part I of this report.

The previous crop was grass. The land was thoroughly prepared. The ridges were 27" apart and the fertilizer (10-10-18) was applied at the rate of 7 cwt. per acre. For Experiment 1, one sub-experiment was carried out in the demonstration plot area at Bush House, to study the growth and development during the growing period of the crop. No sub-experiment was conducted for the Experiment 2.

The main experiments were planted between 28th. April and 1st. May, 1961 in cool cloudy weather, with frequent drizzling rain.

THE MAIN EXPERIMENTS

Treatment and Layout:

EXPERIMENT 1 - All combination of the following factors:

(a) Variety (v):

(i) Arran Pilot

(ii) Majestic

(b) Spacing (s):

(i) 9"

(ii) 18"

(c) Seed Size (z):

(i) Large (120-140 g.)

(ii) Small (80-110 g.)

(d) Storage Conditions:

(i) 40^{o}F.

(ii) Treated with TCNB and stored in farm barn at ambient temperature.

(e) Chitting Period (in the light):

(i) 4th. November to 28th. April.

(ii) 2nd. December to 28th. April.

(iii) 4th. January to 28th. April.

(iv) 9th. February to 28th. April.

(v) No chitting.

(Details of the environment during chitting are given in Table 39).

EXPERIMENT 2

(a) Variety (v):

(i) Arran Pilot.

(ii) Majestic.

(b) Chitting Period (D):

(i) 4th. November to 30th. April.

(ii) 2nd. December to 30th. April

(iii) 4th. January to 30th. April.

(iv) 9th. February to 30th. April.

(v) No chitting.

(c) Sprout-length Levels (L):

(i) Short (L_1)

(ii) Medium (L_2)

(iii) Long (L_3)

The seed size used throughout was on average 90 g. per set. (Details of the environment during chitting are given in Table 40). They were planted in 27" drill at 18" spacing.

The Layout - Experiment 1

The main experiment was of split-plot design. There were two replications. Each replication was divided into two main plots to accommodate the two varieties which were allocated at random. Each main plot was then split into four sub-plots to include the two factors, spacing and seed size (2 x 2), which also were allocated at random. Each sub-plot was then split into sub-sub plots to accommodate

10 treatments (2 x 5) resulted from the two types of storage conditions (low temperature and TCNB application), and the five dates of chitting, the treatments again being allocated at random. The total number of plots for the experiment was 160 (2 x 2 x 2 x 2 x 2 x 5).

Experiment 2

This experiment was also of split-plot design. There were two replications. Each replication was divided into two main plots to accommodate the two varieties which were allocated at random. Each main plot was then split into five sub-plots to include the dates of chitting. Each sub-plot was then split into three sub-sub plots to accommodate these treatments of sprout length levels. The total number of plots for the entire experiment was 60 (2 x 2 x 5 x 3).

In each experiment the area harvested from each plot was $\frac{1}{1075}$ acre (9.0 x 4.5 ft.). There were 24 tubers per plot planted at 9" spacing in Experiment 1, and 12 tubers at 18" spacing in Experiment 1 and 2. There was a discard drill planted with Majestic between two adjacent plots, while across the ends of the plots Kerr's Pink were planted to act as discards and markers.

THE SUB-EXPERIMENT

Treatment and Layout:

The treatments were the same as in the main-experiment, except that the tubers were planted only at 18" spacing.

The sub-experiment was conducted with 12 seed tubers of each variety and seed size. It was of split-plot design. There were three replications. Each variety was planted in a separate plot of ground, the two plots being separated by a 4 yard grass strip. Each area was divided into three replications. Each replication was split into four blocks to enable plants to be lifted at four dates. A discard row was used in between the replications. Each plot was divided into two sub-plots to include the two seed sizes which were allocated at random. Each sub-plot was then planted with 10 seed tubers one from each of the 10 treatments. Across the plots one discard tuber was planted as a marker.

Dates of Field Operation and Observation

(1.) Planting:

(i) Experiment 1 - 28th. April and 29th. April, 1961.

(ii) Experiment 2 - 1st. May. 1961.

(iii) Sub-experiment - 4th. May, 1961.

(2.) Harrowing:

(i) Main-experiments - 9th. May, 1961.

(ii) Sub-experiment - 15th. May, 1961.

(3) Cultivation

Main-experiment - 30th. May, 1961.

(4) Ridging

Main-experiment - 8th. June, 1961.

(5) Sampling - Sub-experiment

(i) First sampling - 26th. June, 1961.

(ii) Second Sampling - 17th. July, 1961.

(iii) Third Sampling - 7th. August, 1961.

(iv) Fourth Sampling - 28th. August, 1961.

(6) Spraying for late-blight protection

(i) First spray - 24th. to 28th. July, 1961.

(ii) Second spray - 22nd. August, 1961.

(7) Harvesting

(i) Experiment 1 - 29th. September to 4th. October, 1961.

(ii) Experiment 2 - 5th. October, 1961.

(8) Grading

(i) Experiment 1 - 10th. October, 1961.

(ii) Experiment 2 - 11th. October, 1961.

Sampling of the Sub-experiment

One plot comprising plants of 10 treatments (2 x 5) were lifted from the one area so that the blanking thus made did not affect the plants of the neighbouring plot. Other procedures, such as the use of polethene bags etc., were similar to those used in the previous year.

Dry Matter Determination and Measurement of Plants

The above-ground stem was cut-off and measured, and tubers were graded into standard sizes (ware, seed and chats), and the above-ground stems and tubers were dried in the electric oven to determine the dry matter content as in the previous year.

Data Collected on Main Experiments

The following records were made from the main-experiments:

1. The number of plants emerged twice a week.
2. The number of above-ground stems.
3. The yield and number of the crop of different grades, viz. ware (over $2^1/_4$" mesh riddle), seed ($2^1/_4$" x $1^1/_4$") and chats (through $1^1/_4$" mesh riddle).

Data Collected from the Sub-experiment

1. The emergence of plants twice a week.
2. The number of main-stems, main-stems + stems coming from under-ground branches.
3. Position of main-stems developing from different regions of the mother tuber (i.e. apical, middle and heel region).
4. Number of tubers of different grades.
5. Dry matter of foliage and tubers.

Diseases

In this year the plants were practically free from disease. There were a few stems infected with "black-leg" and these were removed.

No incidence of late-blight (Phytopthora infestans) was noticed in the experiment. However, preventative measures were taken, and two protective sprays of "perenox" at the rate of 4 lb. per acre were applied by means of a hand propelled low volume "atomiser" type sprayer, the first one between 24th. and 28th. July, and the other on 22nd. August.

Harvesting

The net area per plot of the main experiment harvested was two drills, 9 feet long, leaving the discard plants. Whenever any tuber was found rotted due to black-leg (which was rare), a fresh tuber of the same size was replaced from the discard plants. After one week, when the soil sticking to the tubers dried, grading was done by machine. The number and weight of each grade was noted separately for each individual plot.

Weather Features

The weather conditions during 1961 were a little different from those in 1960 during May and June. Although the total rainfall for those two months was not less than in 1960. the distribution was not uniform.

There was some frost damage on May, 30th. to the young plants at the time of emergence. One or two apical leaves of the plants seemed to be damaged, but in a week's time the plants were free from this damage. The temperature and sunshine was average for the growing period, except that the planted seed tubers faced a longer period of cold weather than during 1960. This resulted in a slight delay in the emergemce of plants compared with the 1960 crop. The meteorological data for the year 1961 is given in Table 52.

TABLE 52

Weather Report, 1961

Months	Temperature ($^{\circ}F$)		Rainfall	Av. Sunshine
	Min.	Max.	(inches)	per day
January	30.6	40.5	3.73	0.81
February	36.1	46.3	2.40	2.96
March	40.1	51.2	2.46	3.32
April	39.4	51.0	2.36	2.79
May	41.6	55.7	1.22	4.93
June	46.4	60.1	1.16	4.20
July	48.3	61.2	3.07	4.05
August	48.6	62.2	4.10	4.74
September	48.1	61.8	2.48	3.32
October	42.8	54.3	4.97	3.37
November	35.7	45.3	3.60	2.10
December	27.7	39.06	3.08	0.95

TABLE 53

Experiment 1, 1960-61

Percentage of Plants Emerged at Successive Dates

The Effects of Dates of Chitting on the Emergence of Plants

Dates of Chitting	Arran Pilot								Majestic							
	Days after Planting								Days after Planting							
	20	22	26	29	33	35	39	42	20	22	26	29	33	35	39	42
November	19.7	32.2	76.7	88.5	98.9	100.0	-	-	21.5	32.6	62.8	77.0	92.0	98.2	100.0	-
December	45.1	62.5	92.3	95.4	99.3	100.0	-	-	26.3	32.2	59.3	78.4	90.9	97.5	100.0	-
January	35.7	53.8	90.6	94.4	100.0	-	-	-	27.0	32.2	68.7	84.0	94.0	100.0	-	-
February	35.7	49.6	89.2	93.4	100.0	-	-	-	14.5	21.1	44.7	67.3	87.1	98.2	100.0	-
No Chitting	00.0	00.0	7.6	19.7	59.3	84.7	100.0	-	00.0	00.0	0.3	2.4	6.9	43.4	89.9	100.0

The Effects of Spacing on the Emergence of Plants

9"	27.1	38.7	70.6	75.9	90.6	96.6	100.0	-	18.7	23.2	45.7	60.3	73.2	86.8	95.7	100.0
18"	27.5	41.4	72.7	83.1	93.3	97.5	100.0	-	16.2	24.5	50.2	65.0	76.2	88.7	98.0	100.0

The Effects of Seed Size on the Emergence of Plants

Large Seed	34.4	46.2	73.0	75.5	91.1	97.2	100.0	-	22.9	29.1	56.1	67.2	77.0	88.4	97.7	100.0
Small Seed	20.1	33.0	69.5	81.1	91.9	96.6	100.0	-	12.9	18.1	38.3	56.5	71.3	86.5	95.8	100.0

PLANT GROWTH STUDIES

(i) Plant Emergence - Experiment 1. 1960-61

To study the effect of different storage treatments on the rate of plant emergence, counts were made regularly twice a week from May, 18th. to June, 9th. 1961, as in the previous year.

The data relating to the effect of storage treatments on emergence of plants was subjected to statistical analysis. For this purpose a germination rate index (Bartlett 1937) was worked out for each plot.

The rate index is equivalent to the mean date of emergence. It employs experimental readings at all stages and summarises them by a single value. The analysis of variance is given in Table 123 in the Appendix.

The plants coming up at the successive dates of observation were expressed as a percentage of the number which finally emerged in the case of each treatment.

Emergence of Plants as Influenced by Chitting

Chitting at different periods resulted in a significant difference in the rate of plant emergence and this was true for each variety. Seed tubers sprouted from November until planting gave a lower percentage of emergence of plants in Arran Pilot than those sprouted from December, January or February (Table 53). This result does not agree with the results obtained by a number of investigators (7, 15, 27, 28, 113, 118) who have shown that the earliest sprouted seed tubers emerged first. One reason in this case could be the shorter sprouts (5.2 cm) in seed tubers chitted from November than those sprouted from December or January, which developed sprouts of 8.0 and 7.9 cm. in length respectively, due to etiolation.

TABLE 54

Experiment 1, 1960-61

The Effects of Chitting on the Emergence of Plants

Germination Rate Index

Dates of Chitting	Arran Pilot	Majestic
November	0.584	0.543
December	0.692	0.545
January	0.655	0.562
February	0.650	0.498
No Chitting	0.311	0.173
S.E.	±0.011	±0.011

TABLE 55

Experiment 1, 1960-61

The Effects of Chitting and No Chitting on the Emergence of Plants

Germination Rate Index

Treatment	Arran Pilot	Majestic
Chitting	0.645	0.532
No Chitting	0.311	0.173
S.E.	± 0.006	± 0.006

TABLE 56

Experiment 1, 1960-61

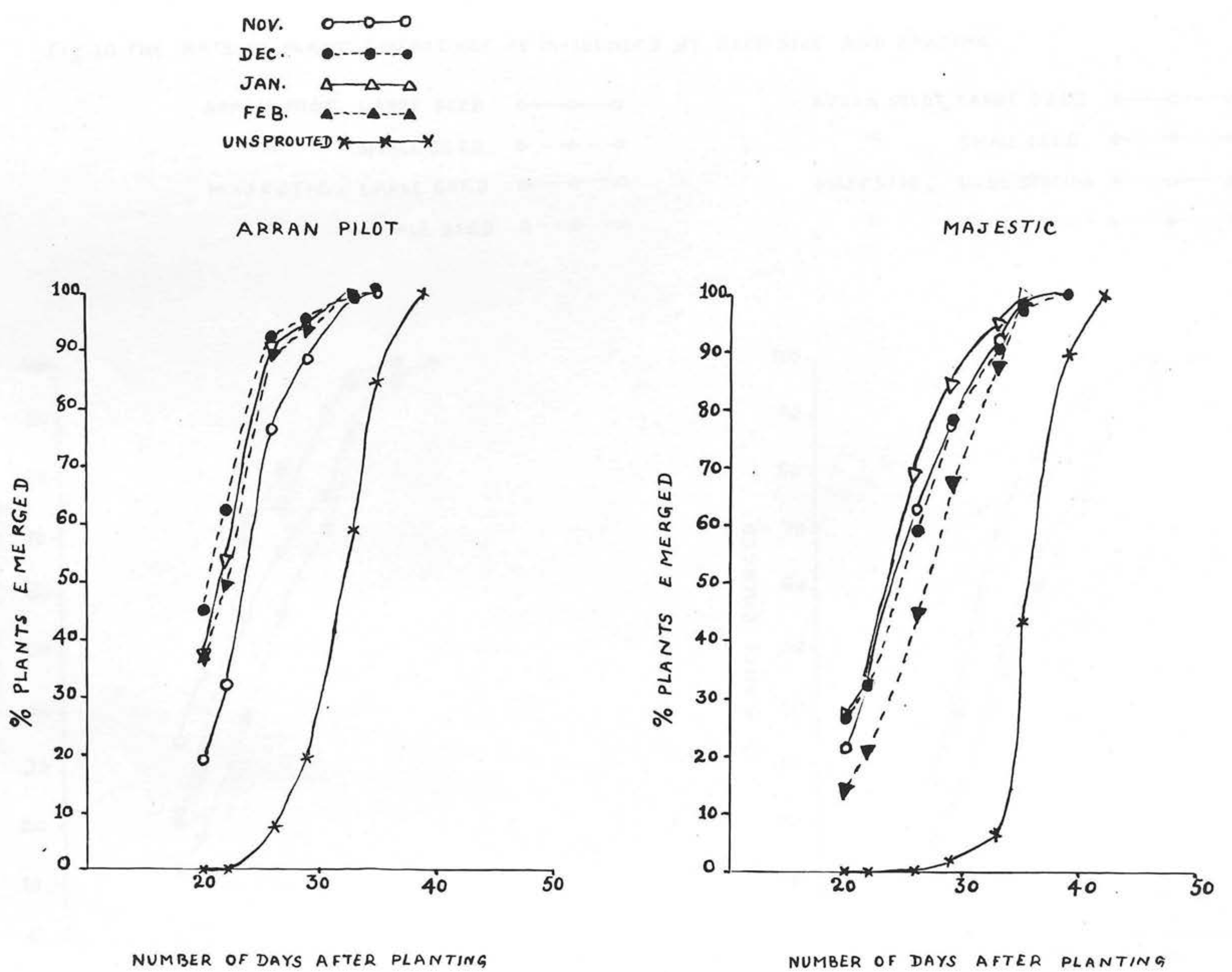
The Effects of Methods of Storage on the Emergence of Plants

Germination Rate Index

Methods of Storage	Arran Pilot	Majestic
Low Temperature Storage	0.573	0.468
TCNB Application	0.582	0.453
S.E.	± 0.007	± 0.007

EXPERIMENT 1, 1960-61

Fig. 9 THE RATE OF PLANT EMERGENCE AS INFLUENCED BY DATES OF CHITTING



EXPERIMENT 1, 1960-61

Fig.10 THE RATE OF PLANT EMERGENCE AS INFLUENCED BY SEED SIZE AND SPACING

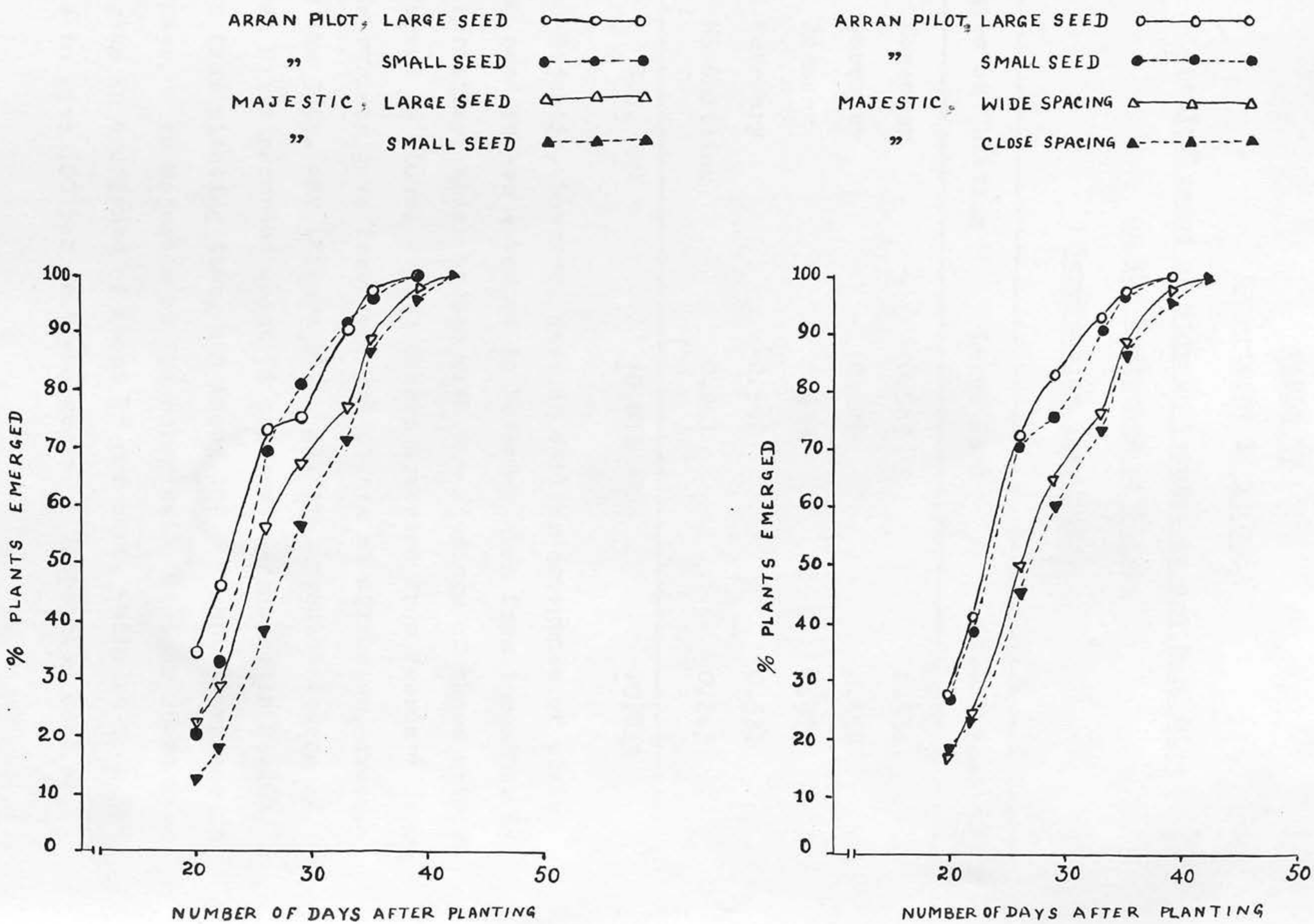


TABLE 57

Experiment 1, 1960-61

The Influence of Storage Treatments and Seed Size on the Emergence of Plants

Germination Rate Index

Dates of Chitting	Large Seed	Small Seed
November	0.589	0.534
December	0.670	0.566
January	0.639	0.578
February	0.597	0.531
No Chitting	0.241	0.243
S.E.	$\pm$0.011	$\pm$0.011

Majestic, however, gave an earlier emergence of plants from seed tubers sprouted in November than from the other dates of sprouting, which agrees with the findings of those authors referred to above. Seed tubers sprouted from February in this variety gave fewer emerged plants at all dates, excluding the 35th. day (Figure 9). All the sprouted tubers of Arran Pilot recorded about 75 per cent emergence in 23-26 days from planting time, and about 100 per cent emergence in 33 days. In Majestic on the other hand, it took 28-29 days to give an emergence of about 75 per cent, while it took 35 days to give 100 per cent emergence. Unsprouted seed of

Arran Pilot started to emerge after 23 days and in 30 days about 25 per cent plants had come up. The rate of emergence after 30 days was very rapid and in a further 9 days period, 100 per cent of the plants had emerged. Unsprouted seed tubers of Majestic on the other hand started emergence 27 days after planting, a difference of 4 days from Arran Pilot, and 25 per cent of the plants were recorded in 35 days. From this period on, the rate of emergence was so rapid that in one week 100 per cent of the plants had come up. Table 55 shows that the difference in the rate of plant emergence between the sprouted and unsprouted seed tubers was highly significant with each variety. The germination rate index for the effects of chitting at different dates and that of low temperature and TCNB is given in Tables 54 and 56 respectively.

TABLE 58

Experiment 1, 1960-61

The Effects of Spacing on the Emergence of Plants

Germination Rate Index

Spacing	Arran Pilot	Majestic	Mean
9"	0.570	0.453	0.511
18"	0.586	0.468	0.527
S.E.	±0.012	±0.012	±0.009

TABLE 59

Experiment 1, 1960-61

The Effects of Seed Size on the Emergence of Plants

Germination Rate Index

Seed Size	Arran Pilot	Majestic	Mean
Large	0.602	0.493	0.547
Small	0.554	0.428	0.491
S.E.	±0.012	±0.012	±0.009

TABLE 60

Experiment 1, 1960-61

The Effects of Spacing and Seed Size on the Emergence of Plants

Germination Rate Index

Seed Size	9"	18"
Large	0.537	0.558
Small	0.486	0.496
S.E.	±0.012	±0.012

TABLE 61

Experiment 1, 1960-61

The Effects of Variety, Spacing and Seed Size on the Emergence of Plants

Germination Rate Index

Spacing	Arran Pilot		Majestic	
	Large	Small	Large	Small
9"	0.585	0.555	0.489	0.417
18"	0.619	0.553	0.497	0.438
S.E.	±0.017	±0.017	±0.017	±0.017

Spacing

Tables 53 and 58 show the effect of spacing on the rate of plant emergence. Wide spacing (18") always gave a higher percentage, and germination rate index, at all counting dates in both the varieties, but the differences were not significant.

Seed Size

Tables 53 and 59 show that large seed tubers gave a higher percentage and germination rate index than small seed tubers, and the differences were significant at the 5 per cent level. The increase in the rate of emergence was noted in each variety at all dates of chitting (Table 57).

The rate of emergence as affected by spacing and seed size is illustrated in Figure 10 for each variety, where Arran Pilot always emerged earlier than Majestic, and the difference was also significant at the 5 per cent level. However, the rate of emergence of Majestic was similar to that of Arran Pilot and the curve of the one runs parallel to that of the other.

The effects of spacing and seed size, and of spacing and variety and seed size are given in Tables 60 and 61 respectively. Large seed tubers and wide spacing gave a higher rate of plant emergence than small seed tubers and close spacing, but the differences were not significant.

The dates of emergence of plants were also recorded from the sub-experiment. The response to the various storage treatments was exactly like that in the main experiment and no further detail need be given. The small number of plants in this experiment also made it less suitable for this purpose than the main experiment.

(ii) <u>Dry Matter Weight of Foliage and Tubers - Sub-Experiment, 1960-61</u>

Table 62 shows that the unsprouted seed tubers gave a lower dry matter yield of foliage up to July 17th. in both varieties than any of the sprouted seed tubers. This was true for the yield of tubers too. The lower yield of foliage and tubers from unsprouted tubers on June 26th. and July 17th. is due to a delay in plant emergence.

The yield of foliage on August 7th. was, in Arran Pilot, the same for unsprouted tubers and all dates of chitting, but in Majestic decreased in the following order, November; No chitting, December, January and February. The yield of tubers from unsprouted potatoes was lower than from chitted tubers in the first three sampling dates in Arran Pilot and all in Majestic. In the former the unsprouted tubers gave the second highest final yield. By August 28th., the foliage of Arran Pilot was almost dead, while in Majestic about 25-40 per cent of the leaves had turned yellow and had started to die, in the plants from sprouted tubers. This resulted in a reduction in the yield of foliage in both varieties. By this time, plants of unsprouted seed gave a higher yield of tuber than those of chitting from December, January or February in Arran Pilot, while in Majestic the unsprouted seed gave a lower yield of tubers than sprouted ones.

TABLE 62

Sub-Experiment, 1960-61

Weight of Dry Matter (g.) of Foliage and Tubers at Different Stages of Plant Growth

Weight of Foliage (g.) per Hill

Dates of Chitting	Arran Pilot				Majestic			
	June 26	July 17	August 7	August 28	June 26	July 17	August 7	August 28
November	21	46	51	19	18	62	96	71
December	22	37	52	15	18	62	86	67
January	20	41	46	13	20	73	80	77
February	21	37	48	9	18	59	79	66
No Chitting	16	34	49	25	9	42	90	66

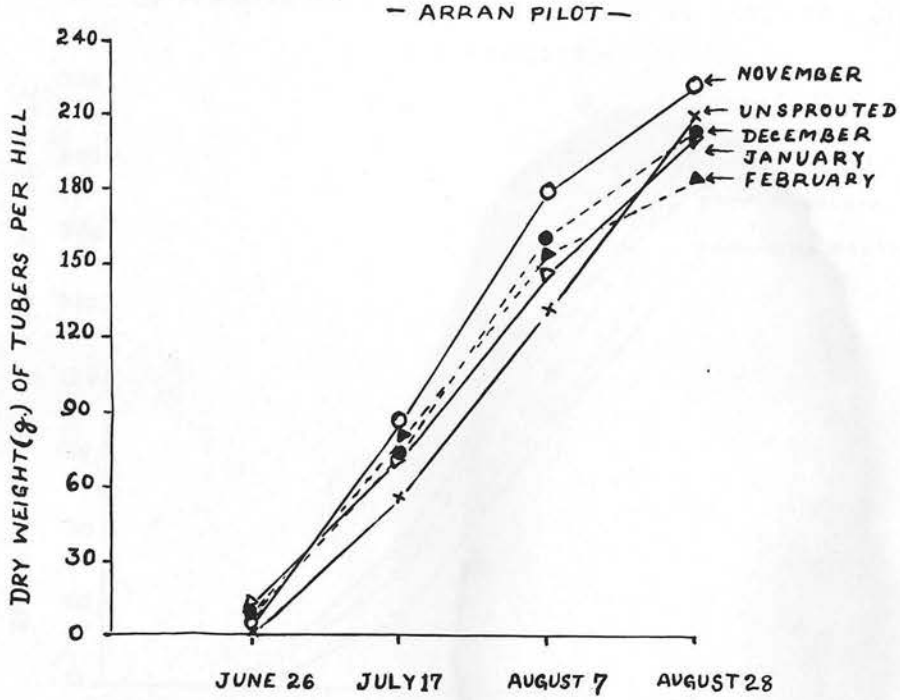
Weight of Tubers (g.) per Hill

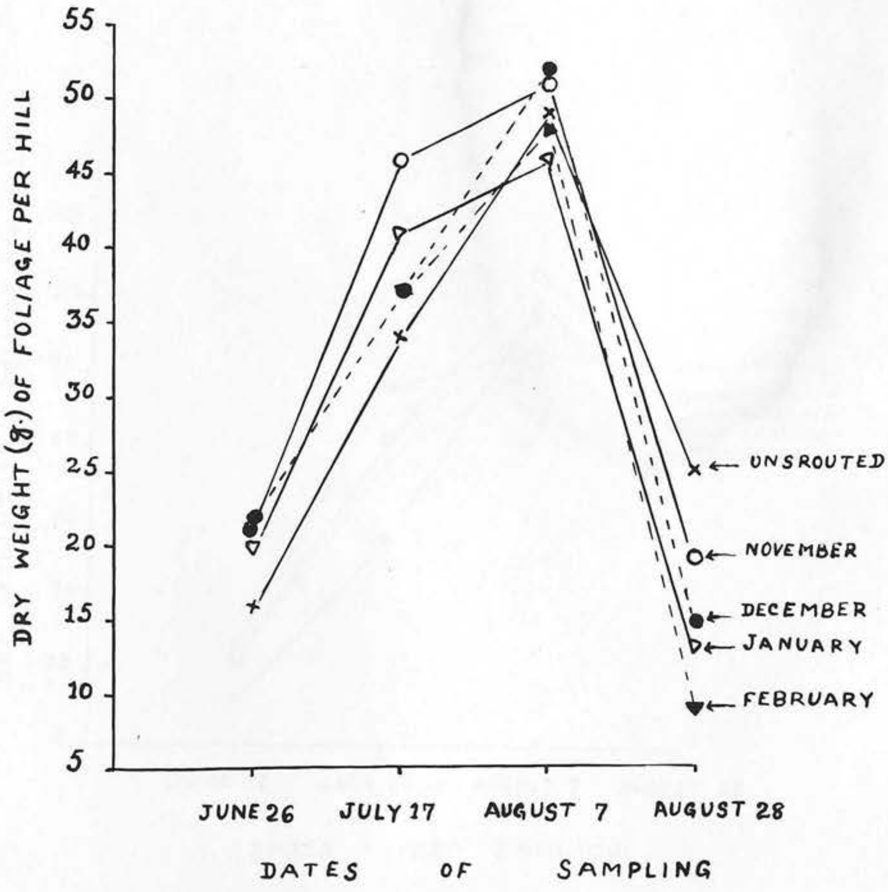
November	6	88	180	224	3	65	206	277
December	9	75	172	205	4	70	171	307
January	13	73	147	202	6	80	194	307
February	11	83	155	186	5	64	151	268
No Chitting	4	57	132	216	1	39	150	242

SUB-EXPERIMENT, 1960-61

Fig.11 DRY WEIGHT OF FOLIAGE AND TUBERS AT DIFFERENT STAGES OF PLANT-GROWTH AS INFUENCED BY DATES OF CHITTING

— ARRAN PILOT —

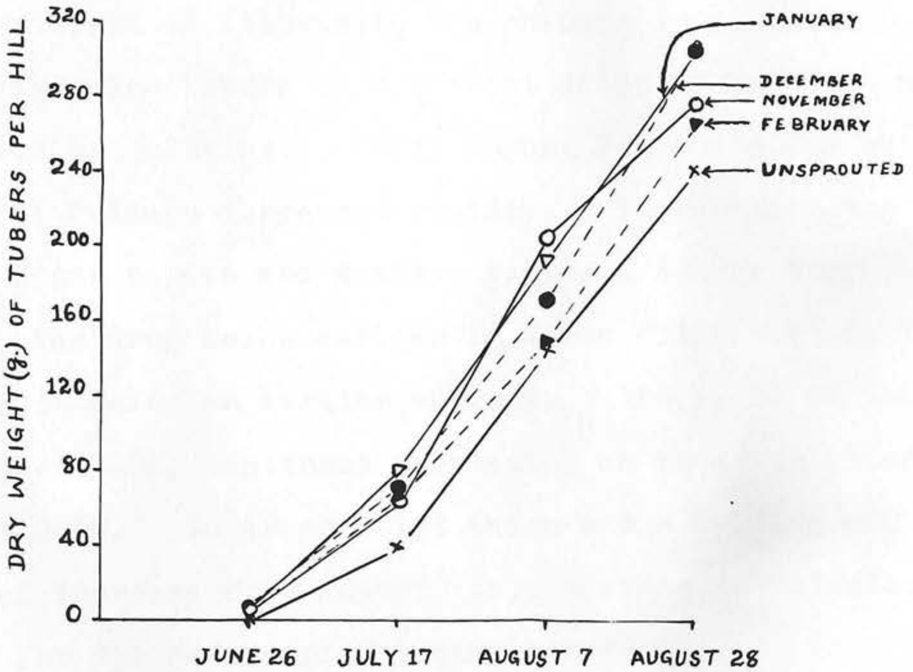


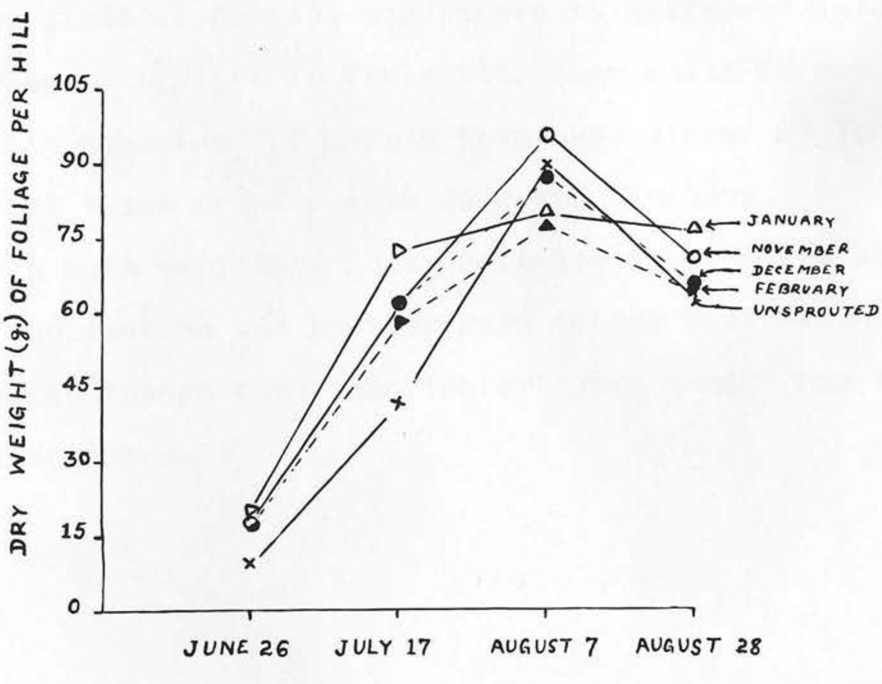


SUB-EXPERIMENT, 1960-61

Fig. 11A DRY WEIGHT OF FOLIAGE AND TUBERS AT DIFFERENT STAGES OF PLANT-GROWTH AS INFLUENCED BY DATES OF CHITTING

—MAJESTIC—





DATES OF SAMLING

Seed tubers sprouted at the different dates gave a very similar growth curve for foliage and tubers. Figures 11 and 11A are drawn to illustrate the changes in dry matter weight of foliage and tubers at different dates of sampling as influenced by chitting. Until August 7th., the dry matter yield of foliage increased rapidly. Thereafter, the foliage parts began to die and wither, giving a sudden drop in the curve, the drop being earlier in Arran Pilot than in Majestic due to it being an earlier variety. The yield of tubers, on the other hand, continued increasing in both varieties till August 28th. In Arran Pilot there was a falling off in the rate of increase from August 7th., whereas in Majestic the curve for the same period became steeper.

The effects of low temperature storage and TCNB application and of large and small seed, in the changes in the dry matter yield of foliage and tubers at different dates of chitting, are given in Table 111, from which it can be said that the behaviour of plants from seed stored at low temperature and those treated with TCNB was similar.

In both varieties under both low temperature storage and TCNB application the heavier seed tubers produced higher yields of tubers than the lighter types except for the final sampling dates.

(iii) Height of Plant

The length of the above-ground stem was measured at the first two sampling dates. The data is given in Table 63. Up to June 26th. (first sampling) Arran Pilot grew vigorously and was not inferior to Majestic. Later Arran Pilot gave a slow growth and was over-taken by Majestic.

The date of chitting did not affect the height of the plant in either variety. However, on the average, there was a trend for the early chitted seed tubers to produce taller plants. The plants from unsprouted tubers were slightly shorter in Arran Pilot, and considerably shorter in Majestic, due to there being more stems.

The behaviour of plant height from seed tubers stored at low temperature and those treated with TCNB was similar in both varieties. Large seed tubers always tended to produce taller plants than small ones irrespective of variety and storage treatments.

TABLE 63

Sub-Experiment, 1960-61

Average Height (cm.) of the Longest Above-ground Stem

Dates of Chitting	Arran Pilot									Majestic								
	Low Temperature Storage				TCNB					Low Temperature Storage				TCNB				
	Large Seed		Small Seed		Large Seed		Small Seed		Av. of Arran Pilot	Large Seed		Small Seed		Large Seed		Small Seed		Av. of Majestic
	June 26	July 17	June 26	July 17	June 26	July 17	June 26	July 17		June 26	July 17	June 26	July 17	June 26	July 17	June 26	July 17	
November	24	32	18	28	27	41	17	34	27.6	22	57	21	51	24	60	18	46	37.3
December	25	32	22	30	23	36	20	32	27.5	29	55	22	48	19	55	15	50	36.6
January	29	28	20	29	22	36	20	27	26.3	24	50	20	52	24	51	12	48	35.1
February	29	36	20	32	25	28	18	27	26.8	23	51	18	45	20	54	22	47	35.0
No Chitting	20	35	18	29	19	37	13	35	25.7	19	49	14	45	13	48	13	44	30.6

(iv) Number of Above-ground Stems and Tubers per Hill

The number of main-stems and above-ground stems was averaged from plants lifted at all dates of sampling, because the average number of each character was more or less the same at all dates of sampling. However, the number of tubers was averaged only from plants of last sampling, i.e. August 28th. because the average number of tubers per hill generally decreased at successive dates of lifting. During the early stages of tuberization many more tubers developed, but at the later part of the season not all of them continued to grow. The average number of main-stems, above-ground stems, and tubers per hill is shown in the Appendix Tables 112, 113 and 114 respectively.

The main effects of methods of storage (low temperature storage and TCNB application) and size of seed on the development of above-ground stems (main-stems + underground branches) and tubers per hill are also shown in Tables 113 and 114 respectively in the Appendix. There was no difference between low temperature storage and TCNB storage. On the average, large and small seed tubers gave 13.9 and 10.9 above-ground stems per hill respectively in Arran Pilot, while these were only 5.3 and 4.6 in Majestic. Similarly, large seed tubers resulted in a greater number of tubers per hill than small ones, and these were 19.2 and 17.3 tubers per hill in Arran

Pilot, while for Majestic there were 14.3 and 13.1 tubers per hill respectively. This agrees with the results obtained by many authors (1, 22, 144, 150). It is evident that Arran Pilot produced about 1.5 tubers per above-ground stem, while Majestic gave about 2.8 tubers per above-ground stem.

The effect of period of chitting on the development of above-ground stems and tubers is summarized in Table 64.

The two varieties responded quite differently. The greatest number of above-ground stems per hill was obtained from tubers chitted earliest (i.e. November) in Arran Pilot. Chitting from December on, gave little difference in the number of above-ground stems and tubers. Majestic, on the other hand, gave an increase in the number of above-ground stems and tubers as the period of chitting became later. This result agrees with a number of investigators (36, 156, 175) who have shown that multiple sprouting increased the number of above-ground stems and tubers per hill.

The reason why we are getting in Arran Pilot maximum number of above-ground stems and tubers per hill from chitting in November is presumably due to them having more main-stems (i.e. 3.1 main-stems per hill) accompanied by more nodes per dominant sprout (Table 43).

TABLE 64

Sub-Experiment, 1960-61

Relationship Between the Number of Sprouts, Main-Stems, Above-ground Stems and Tubers

Dates of Chitting	Arran Pilot						Majestic					
	Sprouts[1] per Seed Tuber	Sprouts[2] (over 1.0 cm) per Seed Tuber	Main-Stems[3] per Hill	Above-ground stems[4] per Hill	Tubers[5] per Hill	Tubers per Main-Stem	Sprouts per Seed Tuber	Sprouts (over 1.0 cm) per Seed Tuber	Main-Stems per Hill	Above-Ground Stems per Hill	Tubers per Hill	Tubers per Main-Stem
November	10.8	3.2	3.1	14.4	20.1	6.5	4.5	1.1	1.4	4.6	13.0	9.3
December	12.2	2.7	2.9	13.3	17.4	6.0	5.7	1.2	1.5	4.7	12.6	8.4
January	12.9	2.8	2.8	11.9	15.6	5.6	10.7	1.5	1.7	4.9	14.0	8.2
February	14.9	3.0	2.8	11.9	18.4	6.6	13.7	2.1	2.0	6.0	12.0	6.0
No Chitting	+	-	7.2	10.6	19.8	2.7	+	-	4.3	4.8	17.5	4.1

[1]Sprouts: Average of 40 Seed Tubers (See Appendix Table 104)
[2]Sprouts: Average of 40 Seed Tubers (See Appendix Table 104)
[3]Main-Stems: Average of 48 Hills (See Appendix Table112)
[4]Above-ground Stems: Average of 48 Hills (See Appendix Table 114)
[5]Tubers: Average of 12 Hills (See Appendix Table 114).

It seemsthat November was too late for a single sprout to be obtained in Arran Pilot. Tubers of an early variety should therefore be chitted earlier if the aim is to produce a single sprout.

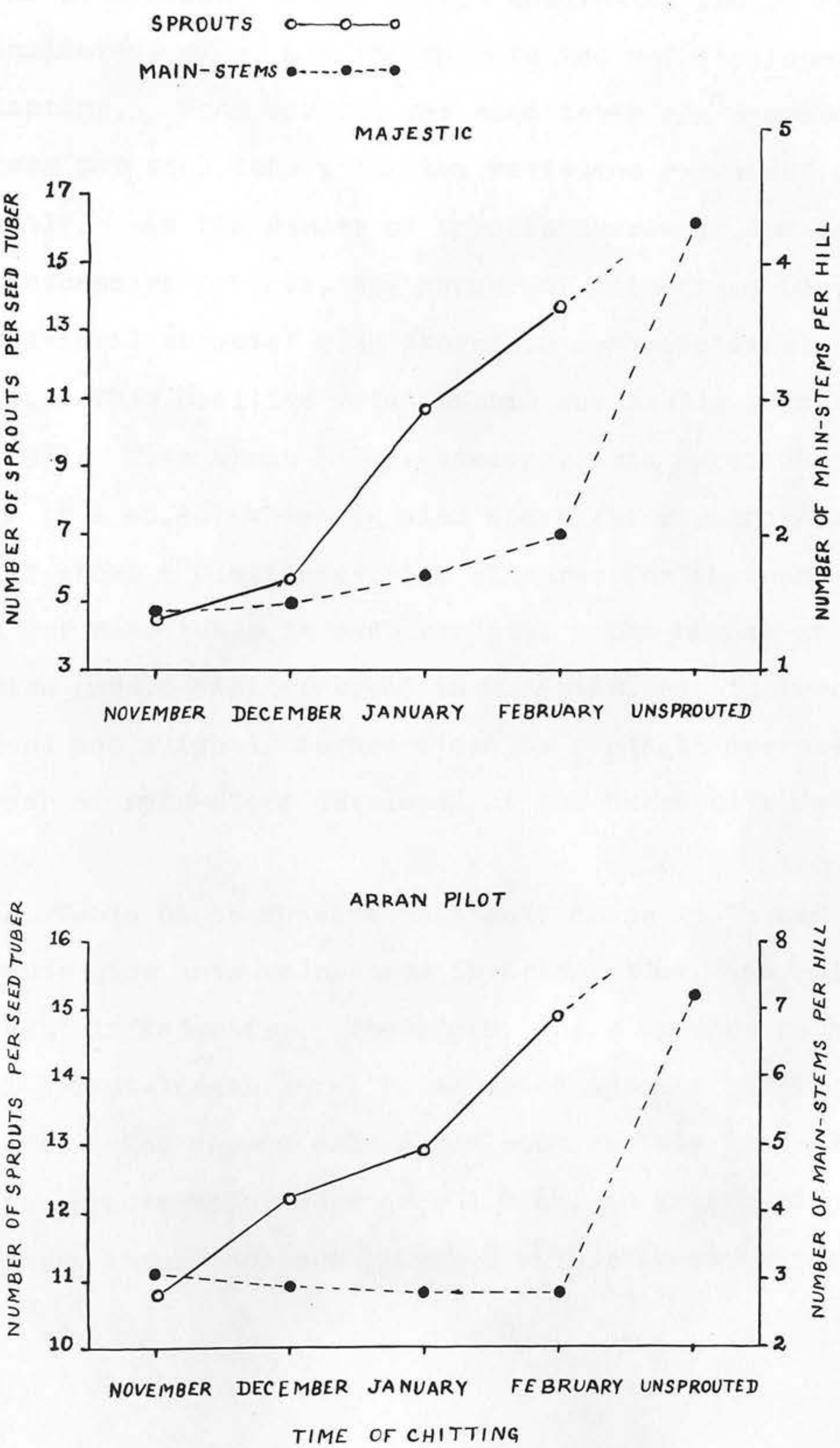
Unsprouted seed tubers gave a higher number of main-stems than sprouted ones in both varieties and seldom produced underground branches. Unsprouted tubers gave the second largest number of tubers in Arran Pilot and the highest number in Majestic. The behaviour of unsprouted tubers in producing more tubers per hill than sprouted ones is therefore a feature and has to be explained. This could be due to the competition between the main-stems for substrate. During the growth analysis it was noticed that more secondary or tertiary stolons were developing from the main-stems of the unsprouted tubers. It seems that it is the number of main-stems per hill which determine the potentiality for producing more tubers.

Relationship Between Number of Sprouts, Main-Stems, Above-Ground Stems and Tubers

From the foregoing facts it appears that a relationship may exist between the number of sprouts, main-stems, above-ground stems, and tubers. Figures 12 to 15 are drawn to illustrate the relationship between each of these characters of plant growth.

SUB-EXPERIMENT, 1960-61

Fig. 12 RELATIONSHIP BETWEEN NUMBER OF SPROUTS PER SEED TUBER AND NUMBER OF MAIN-STEMS PER HILL



(i) Sprouts and Main-Stems

To relate the two characters, the number of sprouts and number of main-stems developed from unsprouted tubers have not been considered, since all the sprouts had not developed before planting. When sprouts per seed tuber are compared with main-stems per seed tuber, the two varieties responded quite differently. As the number of sprouts increased due to chitting at successive periods, the number of main-stems (developed from individual sprouts) also increased correspondingly in Majestic. This positive relationship was highly significant (r = +0.97). With Arran Pilot, however, this relationship was negative (r = -0.86) which is also above the significance level. Figure 12 shows a continuous rise of curve for the number of sprouts per seed tuber in each variety. The number of main-stems also gave a similar trend in Majestic, but in Arran Pilot this trend was slightly downward due to a slight decrease in the number of main-stems developed at the successive dates of chitting.

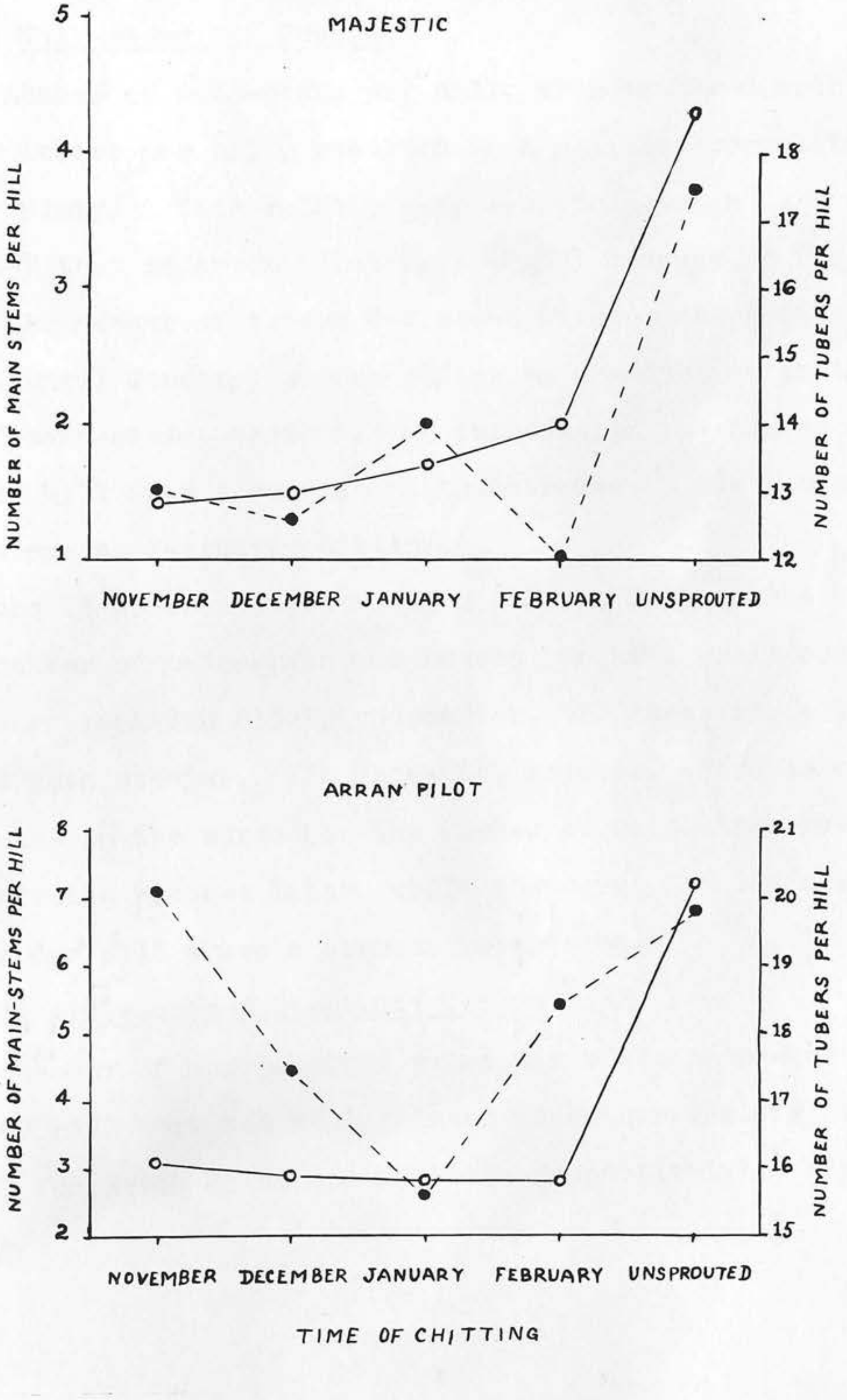
From Table 64 it appears that only about 25-35 per cent of the sprouts grow into main-stems in Arran Pilot, and only 15-35 per cent in Majestic. Therefore, there appears to be a critical sprout-length level below which sprouts won't grow to main-stems. The second column for each variety in Table 64 shows the sprouts which were over 1.0 cm. in length at planting time. When these data are compared with main-stems per hill,

SUB-EXPERIMENT, 1960-61

Fig. 13 RELATIONSHIP BETWEEN NUMBER OF MAIN-STEMS AND NUMBER OF TUBERS PER HILL

MAIN-STEMS o—o—o

TUBERS •----•----•



it is evident that this critical level in Arran Pilot is 1.0 cm. or a little over, whereas in Majestic this critical level appears to be slightly below 1.0 cm. The rest of the sprouts remained suppressed all through the growing period.

(ii) Main-stems and Tubers

The number of main-stems per hill, when compared with the number of tubers per hill, resulted in a positive correlation in each variety. This relationship was stronger in Majestic (r = +0.89) than in Arran Pilot (r = +0.50) because in the latter, although the number of tubers decreased at successive dates of chitting (until January) corresponding to a reduction in the number of main-stems, there was an increase in the number of tubers per hill from a corresponding decrease in the number of main-stems at February chitting.

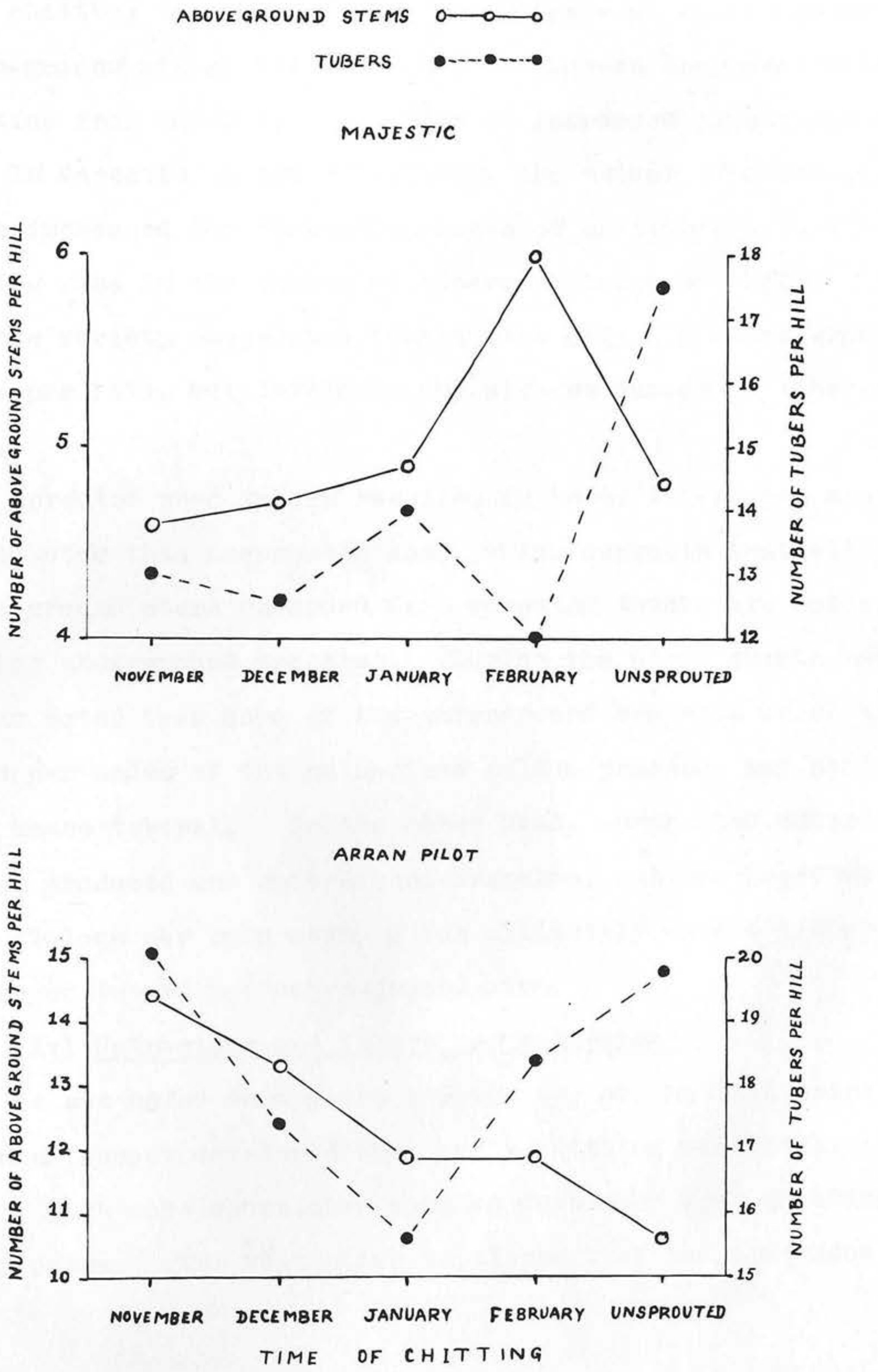
Figure 13 shows that there is a gradual drop in the curve for the number of main-stems and tubers per hill until chitting from January in Arran Pilot, thereafter, the curve for either rises and gets steeper. In Majestic, however, there is a gradual rise in the curve for the number of main-stems per hill as the chitting becomes later, while the curve for the number of tubers per hill shows a corresponding rise.

(iii) Above-ground Stems and Tubers

The number of above-ground stems per hill and number of tubers per hill were not well related in either variety (r = +0.12 and -0.37 for Arran Pilot and Majestic respectively). Figure 14

SUB-EXPERIMENT, 1960-61

Fig.14 RELATION BETWEEN NUMBER OF ABOVE GROUND STEMS AND NUMBER OF TUBERS PER HILL AS INFLUENCED BY DATES OF CHITTING



shows that in Arran Pilot, there was a continuous drop in the number of above-ground stems at all dates of chitting (except that chitting in January and February gave an equal number of above-ground stems) but the number of tubers decreased until chitting from January, thereafter it increased considerably.

In Majestic on the other hand, the number of above-ground stems increased for successive dates of chitting, with a corresponding rise in the number of tubers produced per hill. Also in this variety unsprouted tubers gave only 4.8 above-ground stems per hill, but developed the highest number of tubers per hill.

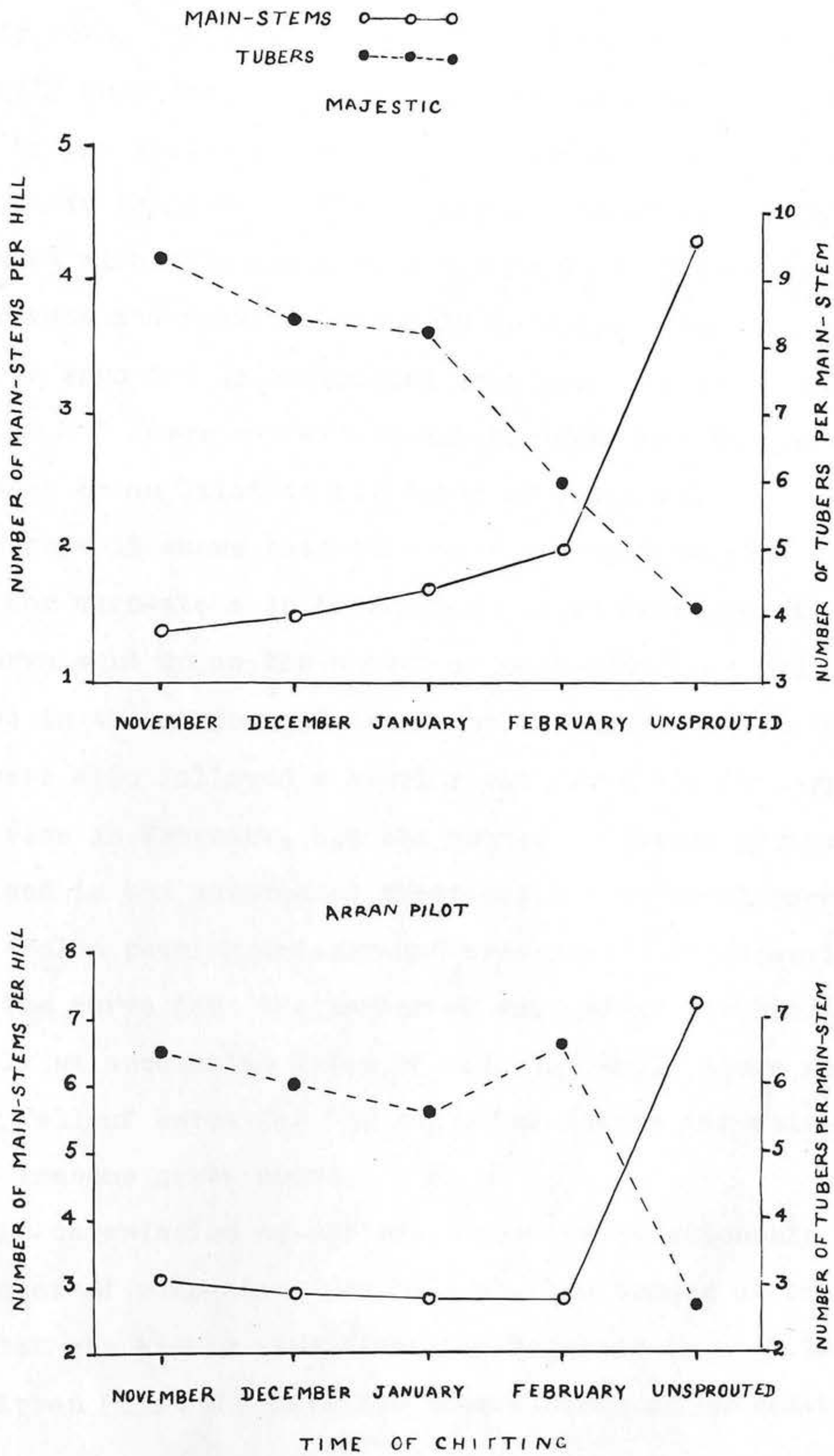
Sprouted seed tubers resulted in fewer tubers per above-ground stem than unsprouted ones, which suggests that all the above-ground stems recorded from sprouted tubers are not stolon bearing underground branches. During the plant growth analysis it was noted that some of the underground branches arising from the upper nodes of the main-stems seldom produced any stolons (and hence tubers). On the other hand, unsprouted tubers seldom produced any underground branches, but developed many more stolons per main-stem, which ultimately gave a higher number of tubers per above-ground stem.

(iv) Main-stems and Tubers per Main-stems

It was noted during the storage period that the apically dominant sprout developed from early chitting was thick and stout, with more nodes than sprouts developed from chitting at later dates. The vegetative development of the individual

SUB-EXPERIMENT, 1960-61

Fig. 15 RELATIONSHIP BETWEEN NUMBER OF MAIN-STEMS AND NUMBER OF TUBERS PER MAIN-STEM.



main-stem was governed to a high degree by the main-stem density, notably that within the hill. As the main-stem density rose, the development of the individual declined. It is hardly surprising, therefore, that the number of tubers produced by the individual main-stem followed a similar pattern, as shown in Table 64. The highly developed single main-stems from seed with only one sprout produced the most tubers and the crowded and relatively poorly developed main-stems from multiple sprouted or unsprouted seed produced the least. Majestic had fewer main-stems and yielded more tubers per main-stem than Arran Pilot at all dates of chitting.

Figure 15 shows that there was a slight decline in the curve for main-stems in Arran Pilot until February, thereafter the curve went up as the number of main-stems per hill increased in the unsprouted treatment. The curve for the number of tubers also followed a similar pattern until January with a small rise in February, but the number of tubers per main-stem decreased in the unsprouted treatment due to development of fewer stolon bearing underground branches. In Majestic, however, the curve for the number of main-stems per hill increased steadily at successive dates of chitting while there was a steady fall of curve for the number of tubers per main-stem due to the reasons given above.

The correlation co-efficient for the relationship between the number of main-stems per hill and the number of tubers per main-stem was highly significant in Majestic ($r = -0.90$), whereas in Arran Pilot the negative co-efficient of correlation was much lower ($r = -0.40$).

The Development of Above-Ground Stems - Experiment 1, 1960-61

A count of the above-ground stems was also made in the main experiment. Above-ground stems were counted on June 16th. (48 days after planting). On this date all the plants from unsprouted tubers had not come up, and so a second count was made on June 30th. (62 days after planting). However, the number of above-ground stems from sprouted tubers had not changed and so the first count was taken for these. The statistical analysis was on the data obtained from each plot and is given in Table 124 in the Appendix.

Above-Ground Stems as Influenced by Chitting

The two varieties responded quite differently in the development of above-ground stems. Table 65 shows that Arran Pilot on the average resulted in about three times as many above-ground stems per acre than Majestic and the difference was highly significant. Also there was a highly significant interaction of dates of chitting and variety. Arran Pilot gave a decrease in the number of above-ground stems as the dates of chitting became later, except chitting from February gave 5 thousand more above-ground stems per acre than that of January, while Majestic produced more above-ground stems as the date of chitting became later. These results are similar to those obtained in the sub-experiment (Table 64), the reasons for which have already been discussed.

TABLE 65

Experiment 1, 1960-61

The Effect of Chitting on the Number of Above-ground Stems

(Thousands per Acre)

Dates of Chitting	Arran Pilot	Majestic
November	296	81
December	276	83
January	262	93
February	267	104
No Chitting	209	100
Mean	262	92
S.E.	±7.5	±7.5

TABLE 66

Experiment 1, 1960-61

The Effect of Chitting and No-chitting on the Number of Above-Ground Stems (Thousands per Acre)

Treatment	Arran Pilot	Majestic
Chitting	276	90
No Chitting	209	100
S.E.	±8.3	±8.3

TABLE 67

Experiment 1, 1960-61

The Effect of Methods of Storage on the Number of Above-Ground Stems (Thousands per Acre)

Methods of Storage	Arran Pilot	Majestic
Low Temperature	273	91
TCNB Application	252	93
S.E.	±4.7	±4.7

TABLE 68

Experiment 1, 1960-61

The Effect of Spacing on the Number of Above-Ground Stems (Thousands per Acre)

Spacing	Arran Pilot	Majestic	Mean
9"	348	119	233
18"	177	65	121
S.E.	±5.0	±5.0	±3.6

The average affect of chitting on the development of above-ground stems was compared with that of no chitting and the result in Table 66 shows that there was a highly significant interaction of chitting and no chitting with variety. Arran Pilot gave 276 and 209 thousand above-ground stems per acre from chitting and no chitting respectively, while Majestic gave 90 and 100 thousands per acre respectively under similar conditions.

There was a significant interaction of methods of storage (low temperature storage and TCNB application) with variety. Low temperature storage produced 21 thousand above-ground stems more than TCNB application in Arran Pilot (Table 67) while the latter gave two thousand more above-ground stems in Majestic.

Spacing.

Table 68 shows that on the average close spacing (9") and wide spacing (18") gave 233 and 121 thousand above-ground stems per acre and the difference was highly significant. On average, close spacing gave 141 thousand more above-ground stems per acre than wide spacing in Arran Pilot, while in Majestic there was an increase of only 54 thousand per acre in favour of close spacing.

When the number of above-ground stems per hill is considered, these were much greater in number at 18" spacing than 9" spacing (not shown in Table) due to the lesser competition for food.

TABLE 69

Experiment 1, 1960-61

The Effect of Seed Size on the Number of Above-ground Stems (Thousands per Acre)

Seed Size	Arran Pilot	Majestic	Mean
Large	281	99	190
Small	244	85	165
S.E.	±5.0	±5.0	±3.6

Seed Size

Table 69 shows that on the average, large seed gave 190 thousand and small seed 165 thousand above-ground stems per acre, and the difference was highly significant. The two varieties gave a similar response; Arran Pilot gave 37 thousand, and Majestic, 14 thousand more above-ground stems per acre in favour of large seed. It should be noted again that Arran Pilot produced about three times as many above-ground stems per acre as Majestic.

The influence of spacing and seed size and the influence of variety, spacing and seed size are given in Tables70 and 71 respectively. These interactions were not significant. The number of above-ground stems per plot is given in Table 115 in the Appendix.

TABLE 70

Experiment 1, 1960-61

The Influence of Spacing and Seed Size on the Number of Above-Ground Stems. (Thousands per Acre)

Seed Size	Spacing 9"	18"
Large	249	133
Small	219	109
S.E.	±5.0	±5.0

TABLE 71

Experiment 1, 1960-61

The Influence of Variety, Spacing and Seed Size on the Number of Above-ground Stems (Thousands per Acre)

Spacing	Arran Pilot		Majestic	
	Large	Small	Large	Small
9"	367	328	127	111
18"	194	160	71	59
S.E.	±7.1	±7.1	±7.1	±7.1

Maturity of Foliage as Influenced by Chitting

The maturity of the plants was scored on two dates, July 26th. and September 24th. The data is given in Table 72.

TABLE 72

Experiment 1, 1960-61

Stages of Maturity of the Foliage

Main Effect of Variety and Interaction of Variety with Dates of Chitting: (Number of Plants Averaged).

Dates of Chitting	Arran Pilot		Majestic	
	July, 26	September, 24	July, 26	September, 24
November	D	F	B	E
December	D	F	A	E
January	D	F	A	E
February	D	F	A	E
No Chitting	A	E	A	C

Key to Stages of Maturity

A Dark green - No sign of yellow foliage

B Yellow green - approximately 25-75 per cent leaves turning yellow.

C Yellow (1) - approximately 75-80 per cent. leaves turning yellow.

D Yellow (ii) - Over 80 per cent leaves turning yellow.

E Vines dead incompletely.

F Vines dead completely.

On July 26th. (i.e. 88 days after planting) over 80 per cent of the plants of Arran Pilot, developed from sprouted tubers at different dates, showed yellowing of the leaves, while Majestic was still dark green in colour. Plants from unsprouted tubers of Arran Pilot, however, were still dark green in colour. On September 24th., plants of Arran Pilot from sprouted tubers were completely dead, while there were a few vines still alive in plants developed from unsprouted tubers. Plants from sprouted tubers in Majestic showed on 80-90 per cent dying off and withering of foliage, while 20-25 per cent of the plants from unsprouted tubers were still partially green and yellow. There was no marked difference in the stages of maturity of plants developed from seed tubers chitted at the different dates, although chitting in November gave slightly earlier maturity than chitting at the later dates.

The results of other factors, such as spacing and seed size are not shown in the Table, but it was noted that close spacing showed earlier maturity than wide spacing, presumably due to the severe competition between the hills. Also plants from large seed tubers gave earlier maturity than those of small seed tubers.

EXPERIMENT 2, 1960-61

(i) Plant Emergence

The plants coming up at the successive dates of observation were expressed as a percentage of the number which finally emerged in the case of each treatment. This percentage was calculated for the interaction of variety with dates of chitting, and variety with sprout length levels.

On the average, Arran Pilot emerged earlier than Majestic, but the difference was not significant.

Table 73 shows that the response to chitting at different dates on the rate of plant emergence was similar to those in Experiment 1, as shown in Table 53, because the tubers of both experiments were chitted on the same dates. No further mention will therefore be made of the effects of chitting at different dates. Table 74 gives the results.

TABLE 73

Experiment 2, 1960-61

Percentage of Plants Emerged at Successive Dates

The Effects of Sprout-length on the Emergence of Plants

Sprout Length Levels	Arran Pilot								Majestic							
	Days after Planting								Days after Planting							
	20	22	26	29	33	35	39	42	20	22	26	29	33	35	39	42
L_1	20.0	25.0	60.0	75.8	95.8	95.8	99.1	100.0	10.8	25.8	53.3	70.8	85.0	91.6	97.5	100.0
L_2	15.8	23.3	70.8	77.5	85.8	94.1	100.0	-	16.3	21.6	41.6	58.3	82.5	93.3	99.1	100.0
L_3	24.1	35.0	63.3	76.6	92.5	97.5	100.0	-	7.5	15.0	31.6	49.1	76.6	90.0	98.3	100.0

The Effects of Dates of Chitting on the Emergence of Plants

November	27.7	34.7	84.7	100.0	-	-	-	-	16.6	27.7	63.8	79.1	94.4	100.0	-	-
December	31.9	45.8	83.3	91.6	100.0	-	-	-	12.5	29.1	48.6	77.7	91.6	98.6	100.0	-
January	16.6	27.3	72.2	87.5	100.0	-	-	-	15.2	23.6	58.3	75.0	100.0	-	-	-
February	23.6	31.9	81.9	94.4	100.0	-	-	-	13.8	23.6	40.2	61.1	88.8	97.2	100.0	-
No Chitting	00.0	00.0	1.3	9.7	56.9	79.1	98.6	100.0	00.0	00.0	00.0	4.1	31.9	62.5	91.6	100.0

TABLE 74

Experiment 2, 1960-61

The Effects of Dates of Chitting on the Emergence of Plants

Germination Rate Index

Dates of Chitting	Arran Pilot	Majestic
November	0.616	0.535
December	0.670	0.508
January	0.561	0.525
February	0.586	0.471
No Chitting	0.271	0.210
S.E.	±0.019	±0.019

TABLE 75

Experiment 2, 1960-61

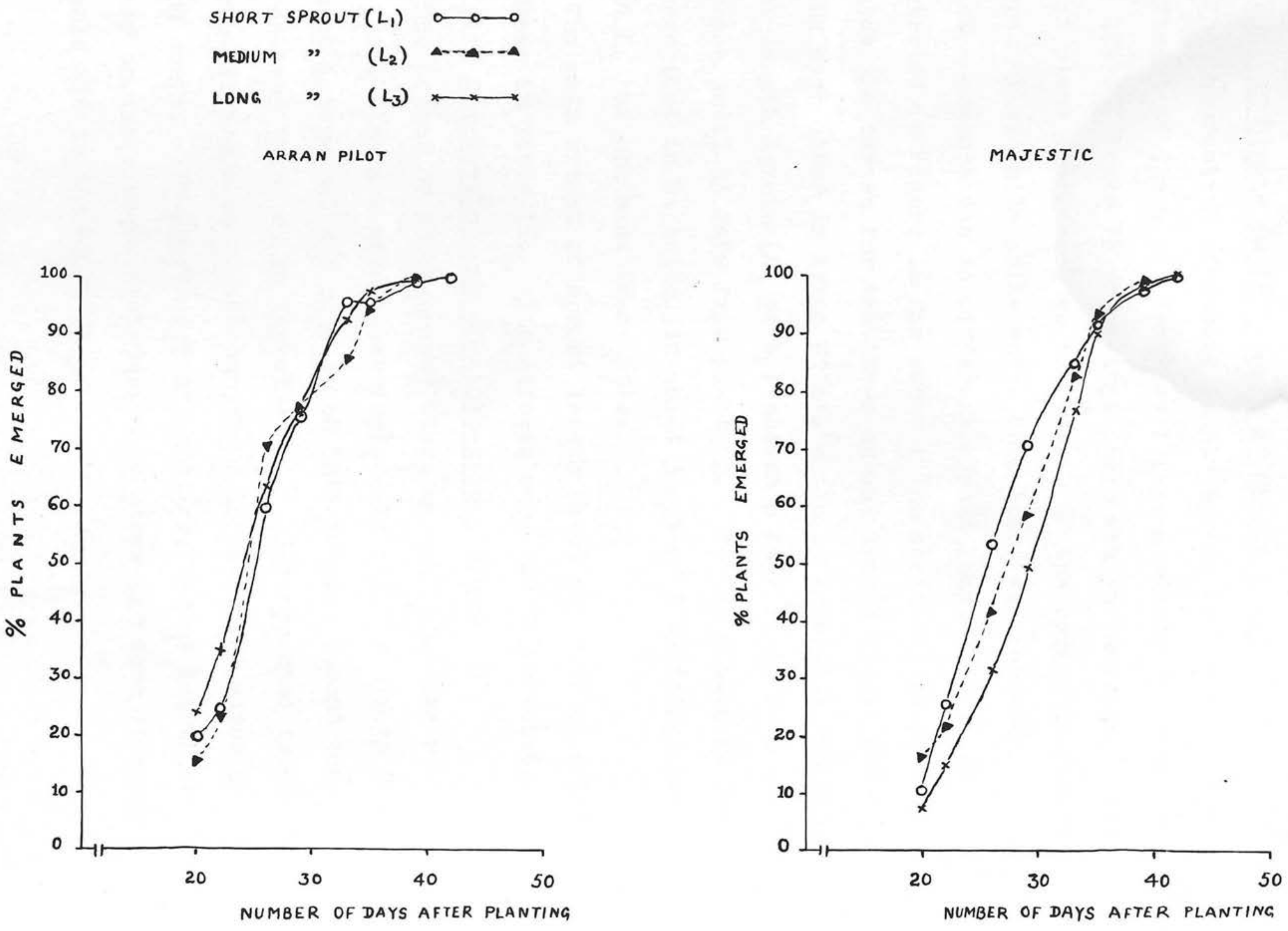
The Effects of Sprout-length on the Emergence of Plants

Germination Rate Index

Sprout Length Levels	Arran Pilot	Majestic
L_1	0.564	0.554
L_2	0.597	0.518
L_3	0.616	0.459
S.E.	±0.024	±0.024

EXPERIMENT 2, 1960-61

Fig. 16 THE RATE OF PLANT EMERGENCE AS INFLUENCED BY LENGTH OF SPROUTS



Emergence of Plants as Influenced by Sprout Length

The interaction of sprout length levels with variety was significant at the 5 per cent level (see analysis of variance Table 125). Table 75 shows that there was an increase in the rate of plant emergence, as the length of the sprout increased in Arran Pilot while in Majestic this trend was reversed. The rate of emergence due to different sprout length levels is illustrated in Figure 16 for each of the varieties separately, in which the curves for the three sprout length levels are overlapping each other in Arran Pilot, while in Majestic, the shorter sprout length levels (L_1 or L_2) showed a more rapid rate of emergence until 33 days from planting. But it should be pointed out here that in Majestic, in about 3 out of 5 chitting dates, L_2 and L_3 had the same treatments.

The main effect of sprout length level and date of chitting are shown in Table 76. The effects were not significant.

(ii) The Development of Above-ground Stems

The number of above-ground stems on each plot was recorded on June 17th. (48 days after planting). As all the plants from unsprouted tubers had not come up on this date, a second count was made on June 30th. as in Experiment 1. The sprouted tubers did not show an increase in the number of above-ground stems on the second count. The influence of chitting, sprout length and variety on the number of above-ground stems per acre is shown in Table 116 in the Appendix.

The behaviour of the two varieties and their interaction with chitting at different dates was similar to that described for Experiment 1 and need not be considered further.

TABLE 76

Experiment 2, 1960-61

The Effects of Chitting and Sprout-length on the Emergence of Plants

Germination Rate Index

Dates of Chitting	L_1	L_2	L_3
November	0.559	0.636	0.531
December	0.571	0.513	0.589
January	0.518	0.571	0.541
February	0.587	0.511	0.488
No Chitting	0.259	0.197	0.265
S.E.	±0.003	±0.003	±0.003

Above-ground Stems as Influenced by Sprout-length

Although the intention was to create different sprout lengths, the treatments could be regarded more correctly as length of time under conditions suitable for chitting, since one short spell in poor light caused all sprout internodes to elongate. The three sprout length levels in Arran Pilot thus became L_1= 5.3 cm, L_2= 6.6 cm, and L_3= 6.5 cm., while in Majestic they were 2.4 cm, 2.2 cm, and 2.5 cm. respectively.

Analysis of variance (Table 126 in the Appendix) shows that sprout length did not affect the number of above-ground stems significantly, nor was the interaction of sprout length level with variety significant.

TABLE 77

Experiment 2, 1960-61

The Influence of Sprout-length on the Number of Above-ground Stems (Thousands/Acre)

Sprout-length Levels	Arran Pilot	Majestic
L_1	181	62
L_2	176	60
L_3	155	62
S.E.	± 6.6	± 6.6

However, Table 77 shows that there was a trend for an increase in the number of above-ground stems as the sprout length decreased in Arran Pilot, while in Majestic there was apparently no difference between each of the levels, L_1, L_2, and L_3, producing 62, 60 and 62 thousand above-ground stems per acre respectively. The potentiality of the short sprouts in producing more above-ground stems in Arran Pilot could perhaps be due to the development of more nodes per dominant sprout (Table 49) as a result of being stored at a low temperature in the barn for a longer period than the other sprouting treatments, and also longer than Majestic. It should be mentioned here again that in Majestic, in about 3 out of 5 chitting dates, L_2 and L_3 had the same treatments. Comparisons between L_2 and L_3 are therefore likely to be of little value for this variety.

TABLE 78

Experiment 2. 1960-61

The Influence of Chitting and Sprout-length on the Number of Above-ground Stems (Thousands/Acre)

Dates of Chitting	L_1	L_2	L_3
November	131	115	111
December	110	126	105
January	134	104	113
February	109	128	103
No Chitting	100	100	109
S.E.	± 9.4	± 9.4	± 9.4

The two-way Table for chitting date and sprout-length level on the development of above-ground stems, is shown in Table 78. The interaction of chitting date and sprout-length level was not significant. The other non-significant interaction of variety, sprout-length level and chitting dates is given in Table 116 in the Appendix as mentioned before.

TABLE 79

Experiment 2, 1960-61

Stages of Maturity of the Foliage

Main Effect of Variety and Interaction of Variety with Dates of Chitting and Sprout-length Levels

(Number of Plants Averaged)

Dates of Chitting	Arran Pilot						Majestic					
	L_1		L_2		L_3		L_1		L_2		L_3	
	July 26	Sept 24	July 26	Sept 24	July 26	Sept 24	July 26	Sept 24	July 26	Sept 24	July 26	Sept 24
November	D	E	D	E	D	E	A	D	A	D	A	D
December	D	E	D	E	D	E	A	D	A	D	A	D
January	D	E	D	E	D	E	A	D	A	D	A	D
February	D	E	D	E	D	E	A	D	A	D	A	D
No Chitting	A	E	A	E	B	F	A	B	A	B	A	B

Key to Stages of Maturity

A Dark Green - No sign of yellow foliage
B Yellow green - appr. 25-95% leaves turning yellow.
C Yellow (1) - appr. 75-80% leaves turning yellow.
D Yellow (II) - Over 80% leaves turning yellow.
E Vines dead incompletely
F Vines dead completely.

Maturity of Foliage

The maturity of the plants was scored for on two dates, July 26th. and September 24th. as in Experiment 1, and the data is presented in Table 79. No difference in maturity was observed from different sprout-length levels on different dates of chitting in either variety. Plants from unsprouted tubers remained green for a longer period than those of sprouted ones.

SECTION III

TREATMENT EFFECTS

ON

FINAL YIELDS

1960-61

SECTION III

TREATMENT EFFECTS ON FINAL YIELDS - EXPERIMENT 1, 1960-61

The following section will deal with the yield and the number of tubers of different grades. The analysis of variance of the yields and number of all grades of tubers is shown in Table 127, and the yield and number of tubers per plot of different grades are shown in Tables 117 to 122 in the Appendix.

Yields and Number of Tubers as Influenced by Chitting

The main effects of storage treatments were not significant for the total yields of tubers, but they resulted in highly significant differences in the total number of tubers. Table 80 gives the yields and number of tubers as influenced by different dates of chitting. When a comparison was made between the number of tubers produced at the four dates of chitting, the two varieties seemed to respond quite differently. There was a suggestion of a reduction in the number of tubers in Arran Pilot at the successive dates of chitting, while in Majestic the trend was the opposite, and the interaction between dates of chitting and variety was highly significant.

TABLE 80

Experiment 1, 1960-61

The Effects of Chitting on the Yield and Number of Different Grades of Tubers

Yield of Tubers (Tons per Acre)

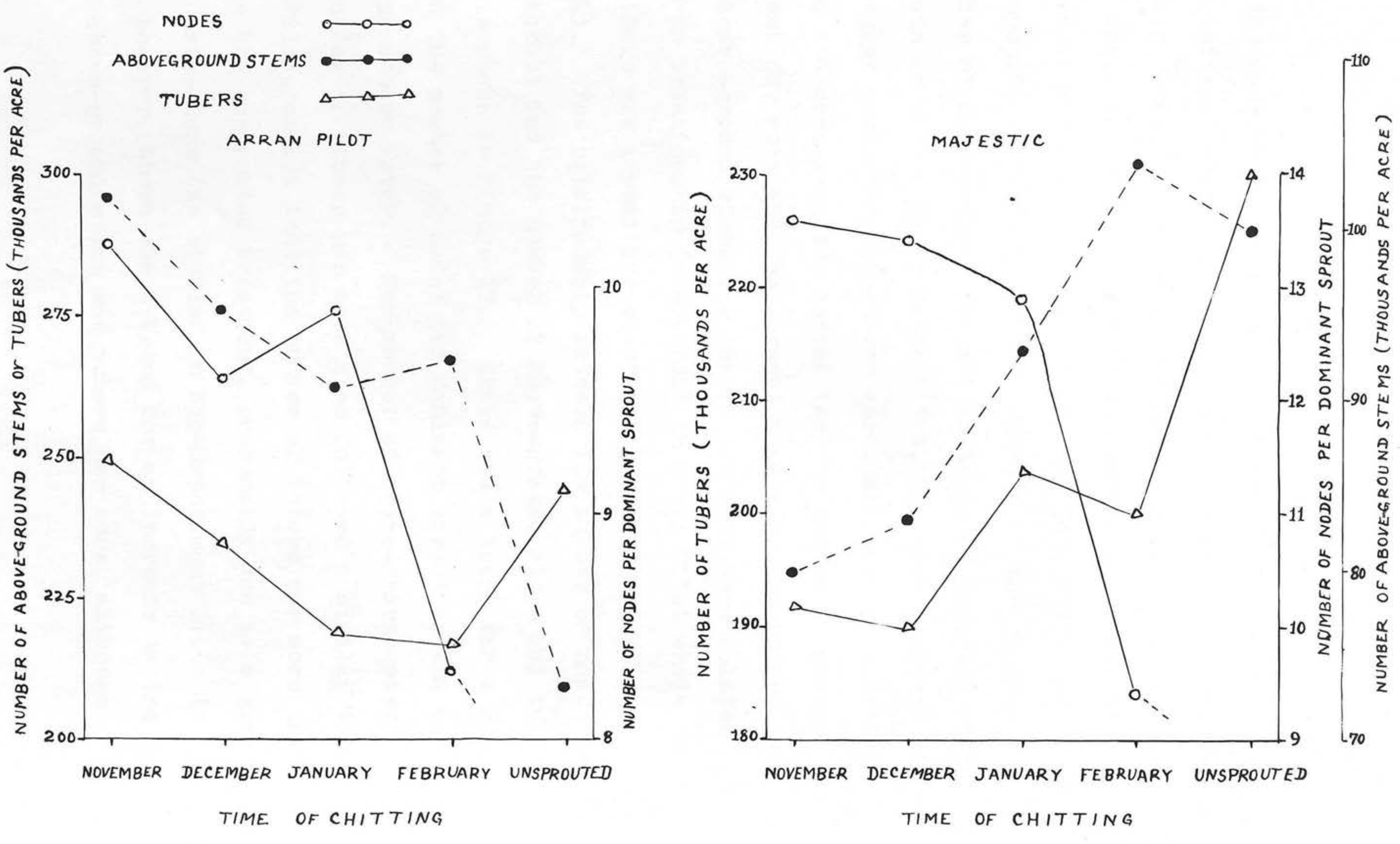
Dates of	Arran Pilot				Majestic			
Chitting	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total
November	3.0	11.8	1.2	16.0	10.6	11.4	0.5	22.5
December	3.0	10.8	1.3	15.1	10.3	11.3	0.6	22.2
January	3.8	10.8	1.0	15.6	9.1	12.4	0.6	22.1
February	3.3	10.9	0.7	14.9	9.0	12.2	0.7	21.9
No Chitting	2.3	12.3	1.3	15.9	5.3	15.1	0.7	21.1
Mean	3.1	11.3	1.1	15.5	8.9	12.5	0.6	22.0
S.E.	±0.4	±0.3	±0.1	±0.4	±0.4	±0.3	±0.1	±0.4

Number of Tubers (Thousands per Acre)

November	13	160	77	250	42	119	31	192
December	13	144	79	236	41	117	32	190
January	16	142	61	219	37	130	37	204
February	16	150	56	222	37	128	35	200
No Chitting	12	170	63	245	24	164	42	230
Mean	14	153	67	234	36	132	35	203
S.E.	±1.8	±4.2	±2.5	±5.8	±1.8	±4.2	±2.5	±5.8

EXPERIMENT 1, 1960-61

Fig. 17 NUMBER OF NODES, NUMBER OF ABOVE-GROUND STEMS AND NUBER OF TUBERS AS INFLUENCED BY DATES OF CHITTING



The increase or decrease in the number of tubers at different dates of chitting may relate to the number of above-ground stems produced per acre. There was a decrease in the number of above-ground stems and in the number of tubers at the successive dates of chitting in Arran Pilot, while the trend was the opposite in Majestic. Unsprouted seed tubers gave a lower number of above-ground stems than those of sprouted ones (at any date of chitting) in Arran Pilot, but they produced the second largest number of tubers per acre, whereas in Majestic, the unsprouted ones gave the second largest number of above-ground stems per acre and the largest number of tubers per acre. When the above-ground stems and tubers per acre were related there was no relationship ($r = -0.04$) in Arran Pilot while in Majestic there was a positive co-efficient of correlation ($r = +0.64$). The relationship between the number of nodes per dominant sprout and the number of above-ground stems and tubers per acre is shown in Figure 17. There was a trend for a reduction in the number of nodes per dominant sprout as the dates of chitting became later. The number of above-ground stems and the number of tubers per acre also followed a similar trend in Arran Pilot, except that the number of tubers per acre increased in the unsprouted treatment, presumably due to a greater number of main-stems (as studied in Sub-Experiment 1). In Majestic, however, there was a trend for an increase in the number of above-ground stems and tubers per acre, although here also the number of tubers per acre increased in the unsprouted treatment corresponding to a reduction in the number of above-ground stems.

The results obtained here were similar to those obtained in the sub-experiment as shown in Table 64, where such a relationship has been fully discussed.

TABLE 81

Experiment 1, 1960-61

The Effects of Chitting and No Chitting on the Yield and Number of Different Grades of Tubers

Yield (Tons per Acre)

Treatment	Arran Pilot				Majestic			
	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total
Chitting	3.3	11.1	1.0	15.4	9.8	11.8	0.6	22.2
No Chitting	2.3	12.3	1.3	15.9	5.3	15.1	0.7	21.1
S.E.	±0.5	±0.3	-	±0.5	±0.5	±0.3	-	±0.5

Number of Tubers (Thousands per Acre)

Chitting	15	149	68	232	40	124	33	197
No Chitting	12	170	63	245	24	164	42	230
S.E.	±2.0	±4.7	-	±6.5	±2.0	±4.7	-	±6.5

When the average yield and number of tubers for the four dates of chitting were compared with those of unsprouted seed tubers, Table 81 shows that there was no significant difference in the yield between them, but the difference in the number of tubers in favour of unsprouted seed tubers was highly significant. Although both the varieties gave a similar trend, a difference of 33 thousand tubers in Majestic and only 13 thousand tubers in Arran Pilot made the interaction of chitting and no chitting with variety, significant at the 5 per cent level.

TABLE 82

Experiment 1, 1960-61

The Effects of Methods of Storage on the Yield and Number of Different Grades of Tubers

Yield of Tubers (Tons per Acre)

Methods of Storage	Arran Pilot				Majestic			
	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total
Low Temp. Storage	2.9	11.4	1.2	15.5	8.9	12.5	0.6	22.0
TCNB application	3.2	11.3	1.1	15.6	8.8	12.5	0.6	21.9
S.E.	±0.3	±0.2	-	±0.2	±0.3	±0.2	-	±0.2

Number of Tubers (Thousands per Acre)

Low Temp. Storage	13	155	70	238	37	133	34	204
TCNB application	15	151	65	231	36	131	36	203
S.E.	±1.1	±2.7	-	±3.7	±1.1	±2.7	-	±3.7

Table 82 shows that low temperature storage and TCNB application produced similar results in total yield and number of tubers per acre for both varieties.

Different Grades of Tubers as Influenced by Chitting

Table 80 shows that chitting at different dates did not give any marked difference in the yields and number of ware in each variety. There was a trend for a reduction in the yields as well as the number of ware tubers as the chitting became later in Majestic, whereas in Arran Pilot, there was no such trend at all, rather there was an increase from chitting in January or February as compared with the chitting in November or December, and the interaction between chitting at different dates and variety was significant for the yield of ware.

Table 81 shows that, on the average, chitting gave higher yields and numbers of ware in each variety than no chitting, and the difference was highly significant. Although the response of each variety was similar, the yield and number of ware in Majestic was about 2 to 3 times greater than in Arran Pilot, and as a result, chitting gave only 1.1 tons ware or 3 thousand ware tubers per acre more than no chitting in Arran Pilot, whereas in Majestic, the differences in the yields and number of ware was 4.3 tons or 16 thousand tubers per acre respectively, which gave a highly significant interaction between chitting versus no chitting and variety. The low yield of ware in Arran Pilot is presumably due to the greater number of tubers per acre produced by Arran Pilot compared to Majestic.

The decrease in the yield of ware is associated with an increase in the yield of seed sized tubers (and chats), and Table 80 shows that there was an increase in the yield and number of seed sized tubers as the chitting became later in Majestic, which is just the opposite situation to that for yield of ware. Arran Pilot, however, behaved differently. There was a slight decrease in the yield and number of seed and chats as the chitting became later (though not steadily), which resulted in a significant interaction between chitting at different dates and variety, both for yield and number of seed sized tubers.

When the average effect of chitting was compared with no chitting on the yield and number of seed sized tubers and chats, Table 81 shows that there was an increase of 1.2 tons and 21 thousand seed tubers per acre in favour of no chitting in Arran Pilot, while in Majestic, the increases due to no chitting were 3.3 tons and 40 thousand seed tubers per acre, which were highly significant. The greater difference in favour of no chitting in Majestic than in Arran Pilot made the interaction between chitting versus no chitting and variety highly significant. Similarly a difference in the yield of chats in favour of no chitting was highly significant and the interaction between chitting versus no chitting and variety was highly significant, because Arran Pilot gave 5 thousand more chats in favour of chitting, while in Majestic, there were 9 thousand more chats in favour of no chitting.

There was a suggestion for a reduction in the yield as well as the number of seed tubers at the successive dates of chitting in Arran Pilot, while the reaction was reversed in Majestic, and this gave a highly significant interaction between different dates of chitting and variety.

TABLE 83

Experiment 1, 1960-61

The Influence of Storage Treatments, Variety and Spacing on the Yield of Seed Tubers (Tons per Acre)

Dates of Chitting	Arran Pilot		Majestic	
	9"	18"	9"	18"
November	13.0	10.6	14.7	8.0
December	11.8	9.8	14.2	8.5
January	11.9	9.6	15.6	9.0
February	12.6	9.2	15.7	8.7
No Chitting	14.2	10.5	17.0	13.2
S.E.	±0.4	±0.4	±0.4	±0.4

The interaction between dates of chitting, spacing and variety was significant at the 5 per cent level suggesting that the effects of chitting at different dates were different at 9" and 18" spacing in both varieties as shown in Table 83.

TABLE 84

Experiment 1, 1960-61

The Influence of Storage Treatments, Seed Size and Spacing on the Yield of Seed Tubers (Tons per Acre)

Dates of	9"		18"	
Chitting	Large Seed	Small Seed	Large Seed	Small Seed
November	14.4	13.3	9.4	9.2
December	13.2	12.8	10.0	8.2
January	14.2	13.3	10.2	8.5
February	15.1	13.2	9.7	8.2
No Chitting	16.0	14.9	12.9	10.8
S.E.	±0.4	±0.4	±0.4	±0.4

The interaction between dates of chitting, spacing and seed size was significant at the 5 per cent level suggesting that the effects of dates of chitting were different at both spacings and seed sizes, as shown in Table 84.

The interaction between dates of chitting and spacing was highly significant for the number of seed tubers suggesting that the effects of chitting at different dates were different at 9" and 18" spacing as shown in Table 85.

EXPERIMENT 1, 1960-61

Fig. 18 NUMBER AND WEIGHT OF TUBERS OF DIFFERENT GRADES AS INFLUENCED BY DATES OF CHITTING

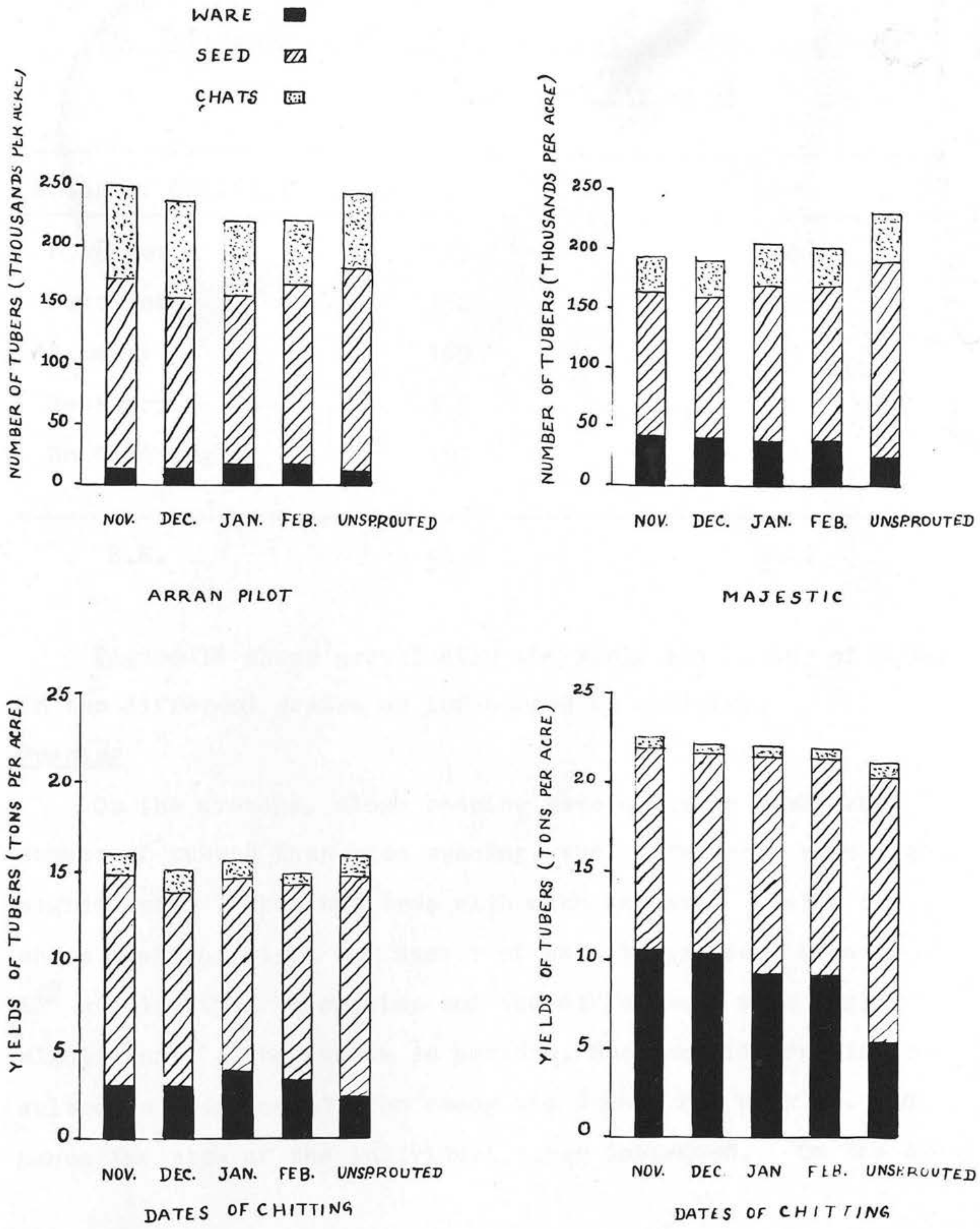


TABLE 85

Experiment 1, 1960-61

The Influence of Chitting and Spacing on the Number of Seed Tubers (Thousands per Acre)

Dates of Chitting	9"	18"
November	171	108
December	152	109
January	169	103
February	175	102
No Chitting	197	135
S.E.	±4.2	±4.2

Figure 18 shows graphically the yield and number of tubers in the different grades as influenced by chitting.

Spacing

On the average, close spacing gave a higher yield and number of tubers than wide spacing, the differences were highly significant. This was true with each variety. Table 86 shows that the yield and number of ware tubers were greater at 18" spacing than 9" spacing and the differences were highly significant. The reason is obvious, because wide spacing resulted in less competition among the tubers for bulking, and hence the size of the individual tuber increased. On the other hand, the yields and the number of seed and chats decreased correspondingly at the wider spacing and the differences were highly significant.

TABLE 86

Experiment 1. 1960-61

The Effects of Spacing on the Yield and Number of Different Grades of Tubers

Yield of Tubers (Tons per Acre)

Spacing	Arran Pilot				Majestic			
	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total
9"	1.6	12.7	1.6	15.9	7.0	15.5	0.7	23.2
18"	4.5	9.9	0.7	15.1	10.8	9.5	0.4	20.7
S.E.	±0.3	±0.3	±0.3	±0.3	±0.3	±0.3	±0.02	±0.3

Numbers of Tubers (Thousands per Acre)

Spacing	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total
9"	8	180	91	279	31	167	44	242
18"	20	126	44	190	42	97	26	165
S.E.	±1.0	±2.8	±3.9	±3.4	±1.0	±2.8	±3.9	±3.4

The interactions of spacing with variety were significant for the yield and number of seed and chats, because Arran Pilot gave a difference of 2.8 tons or 54 thousand seed tubers per acre between 9" and 18" spacing, whereas in Majestic, these differences were 6.0 tons or 70 thousand seed tubers per acre respectively in favour of 9" spacing. Also, Arran Pilot gave a difference of 0.9 tons or 47 thousand chats per acre between 9" and 18" planting, while in Majestic, these differences were only 0.3 tons or 18 thousand chats per acre in favour of close spacing.

Seed Size

Table 87 shows that on the average, large and small seed tubers gave equal yields, i.e. 15.5 tons per acre in Arran Pilot, whereas there was only 0.9 tons per acre extra yield in favour of large seed tubers in Majestic. On the other hand, the difference for the number of tubers in favour of large seed tubers was highly significant. This shows that the tubers derived from small seed were larger in size. The same Table shows that small seed tubers gave 0.6 tons or 2 thousand ware tubers per acre more than large seed in Arran Pilot, whereas in Majestic the differences were 1.2 tons or 3 thousand ware tubers per acre in favour of small seed tubers, the difference being significant at the 5 per cent level.

The yield and the number of seed size and chats increased in favour of large seed in each variety, and the differences were highly significant. There was a significant interaction between seed size and variety for the number of seed tubers. Although each variety gave a similar trend, a difference of 25 thousand seed tubers in favour of larger seed in Majestic is significantly greater than only 10 thousand seed tubers in Majestic.

TABLE 87

Experiment 1, 1960-61

The Effects of Seed Size on the Yield and Number of Different Grades of Tubers

Yield of Tubers (Tons per Acre)

Seed Size	Arran Pilot				Majestic			
	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total
Large	2.8	11.6	1.1	15.5	8.3	13.5	6.6	22.4
Small	3.4	11.0	1.1	15.5	9.5	11.5	0.5	21.5
S.E.	±0.3	±0.3	±0.02	±0.3	±0.3	±0.3	±0.02	±0.3

Number of Tubers (Thousands per Acre)

Large	13	158	70	241	35	144	39	218
Small	15	148	64	227	38	119	31	189
S.E.	±1.0	±2.8	±3.9	±3.4	±1.0	±2.8	±3.9	±3.4

The influence of spacing and seed size and of variety, spacing and seed size on the yield and number of different grades of tubers is given in Tables 88 and 89 respectively. These 3 factor interactions were non-significant.

TABLE 88

Experiment 1, 1960-61

The Effects of Spacing and Seed Size on the Yield and Number of Different Grades of Tubers

Yield of Tubers (Tons per Acre)

Seed Size	9"				18"			
	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total
Large	4.0	14.6	1.1	19.7	7.2	10.5	0.5	18.2
Small	4.8	13.6	1.0	19.4	8.1	9.0	0.5	17.6
S.E.	± 0.3	± 0.3	± 0.02	± 0.3	± 0.3	± 0.3	± 0.02	± 0.3

Number of Tubers (Thousands per Acre)

Large	18	182	72	272	30	164	93	187
Small	21	120	108	249	32	103	32	167
S.E.	± 1.0	± 2.8	± 3.9	± 3.4	± 1.0	± 2.8	± 3.9	± 3.4

TABLE 89

Experiment 1, 1960-61

The Effects of Variety, Spacing and Seed Size on the Yield and Number of Different Grades of Tubers (Tons per Acre).

Spacing	Arran Pilot								Majestic							
	Large				Small				Large				Small			
	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total
9"	1.3	12.9	1.7	15.9	1.9	12.5	1.6	16.0	6.4	16.3	0.8	23.5	7.6	14.6	0.6	22.8
18"	4.2	10.3	0.7	15.2	4.8	9.6	0.7	15.1	10.1	10.6	0.6	21.3	11.4	8.4	0.4	20.2
S.E.	±0.4	±0.4	±0.03	±0.5	±0.4	±0.4	±0.03	±0.5	±0.4	±0.4	±0.03	±0.5	±0.4	±0.4	±0.03	±0.5
	Number of Tubers (Thousands per Acre)															
9"	6	183	95	284	9	176	89	274	29	180	51	260	32	153	39	224
18"	20	132	46	198	21	121	39	181	41	108	27	176	43	86	25	154
S.E.	±1.4	±3.9	±5.5	±4.9	±1.4	±3.9	±5.5	±4.9	±1.4	±3.9	±5.5	±4.9	±1.4	±3.9	±5.5	±4.9

EXPERIMENT 2 - 1960-61

The effects of chitting at different dates on the yield and number of tubers have been discussed in detail in Experiment 1. The following section will be mainly confined to the effect of sprout length on the yield and number of tubers of different grades.

Before any comparison is made on the effect of different sprout-length, it would be worthwhile mentioning here that there was not much difference in the sprout-length levels in either variety. Yet, morphologically each sprout length level was different from the other. For example, the short sprout level, being chitted for a longer period at low temperature in the barn, developed slightly more nodes per dominant sprout (Table 49). Also as mentioned before, in some treatments, tubers of two sprout-length levels were moved to the barn together, so that they were not different from each other. However, the following section will illustrate the reaction of period of chitting in different environments on the development and yield of tubers.

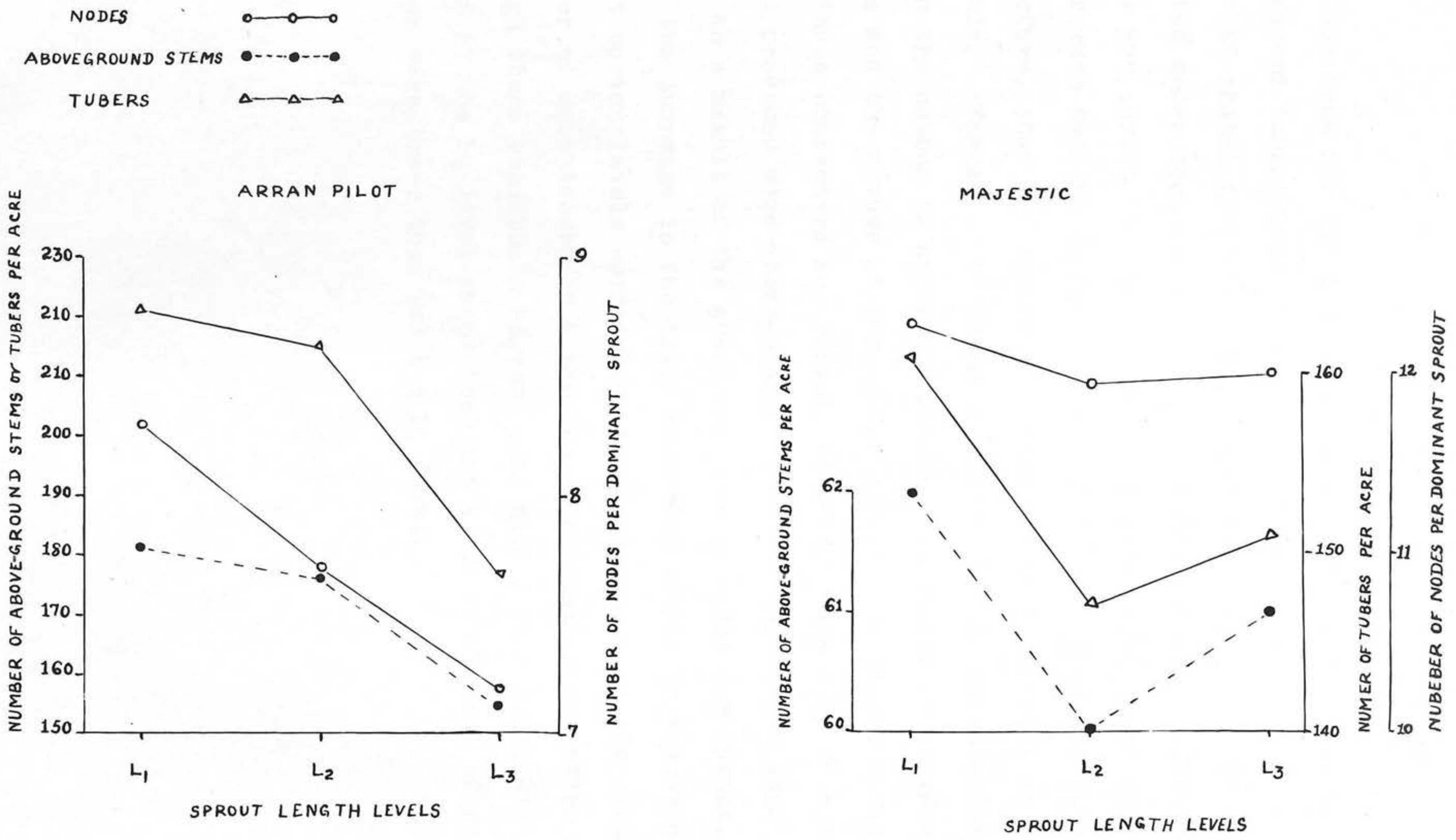
The analysis of variance for the yield and number of tubers of different grades is presented in Table 128 in the Appendix.

Yield and Number of Tubers as Influenced by Sprout-length

Table 90 shows that on average, the three sprout-length levels gave highly significantly different total yield and number of tubers. The short sprout levels (L_1 and L_2) gave higher yields than the long sprout level (L_3) in both varieties.

EXPERIMENT 2, 1960-61

Fig. 19 NUMBER OF NODES, ABOVE-GROUND STEMS AND NUMBER OF TUBERS AS INFLUENCED BY SPROUT LENGTH



This was true for the number of tubers too, except that L_2 gave 3 thousand tubers less than L_3 in Majestic. In Section I, Table 49 showed that the "short" sprouts, i.e. those that were chitted under cool conditions for a longer period, produced more nodes per sprout than the "longer" sprouts, i.e. those chitted under warm conditions for a longer period. It is possible, therefore, that the number of tubers produced per hill is related to this. Figure 19 is drawn to illustrate the relationship between the number of nodes per sprout, the number of above-ground stems and the number of tubers per acre. The figure shows that the three characters are closely related. The "short" sprout level produced more above-ground stems and tubers per acre perhaps as a result of the greater number of nodes per sprout.

The increase in the total number of tubers in favour of short sprout levels corresponds to the decrease in the yield and number of ware tubers in Arran Pilot, whereas in Majestic, although there was also a higher total number of tubers, the lower yield at the L_3 level meant that the yield and number of ware grades were lower than for the L_1 level.

TABLE 90

Experiment 2, 1960-61

The Influence of Sprout-Length on the Yield and Number of Different Grades of Tubers

Yield of Tubers (Tons per Acre)

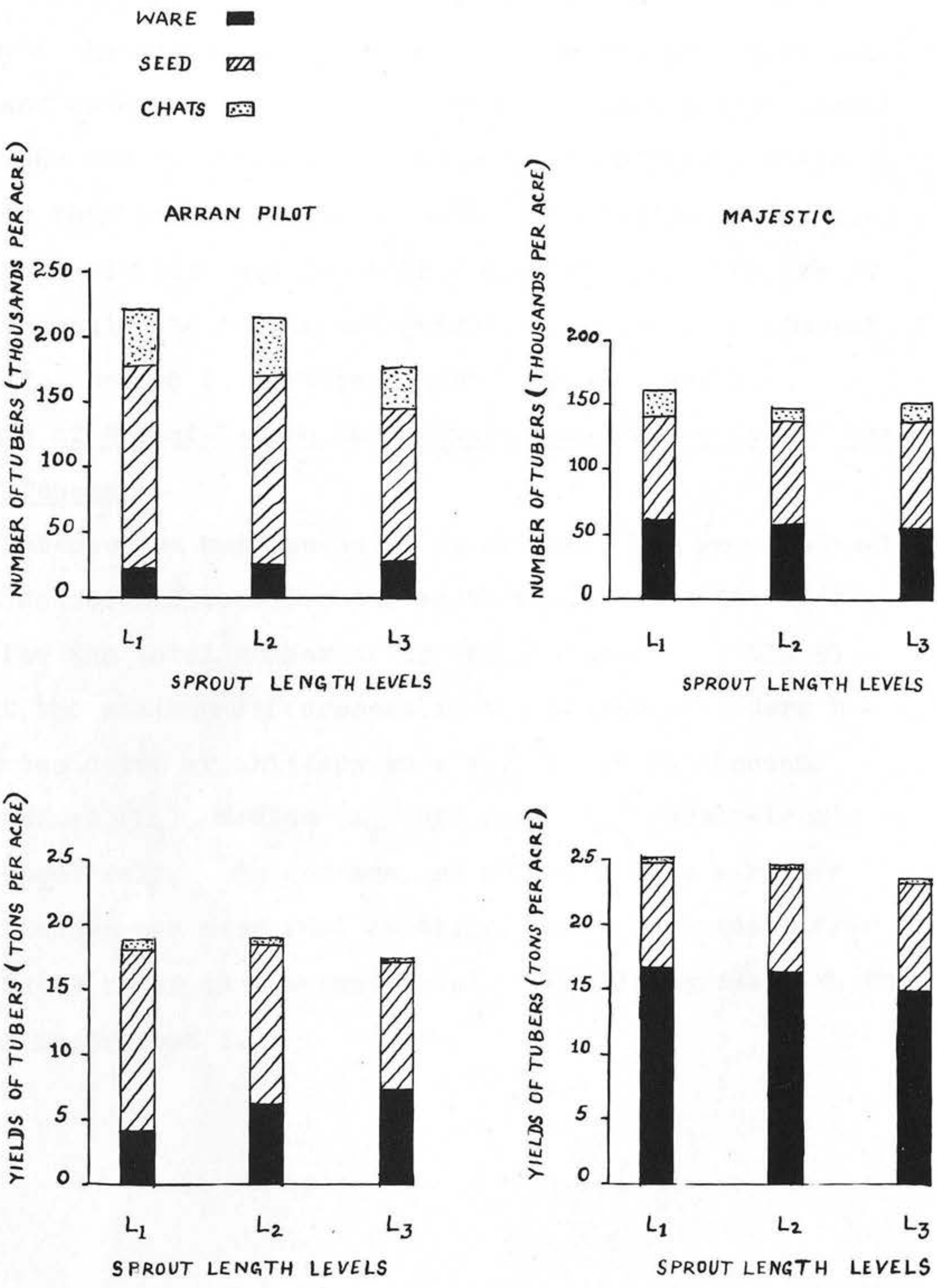
Sprout Length Levels	Arran Pilot				Majestic			
	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total
L_1	4.9	13.1	0.8	18.8	16.6	8.2	0.3	25.1
L_2	6.1	12.1	0.7	18.9	16.4	8.0	0.2	24.6
L_3	7.2	9.6	0.6	17.4	14.9	8.3	0.3	23.5
S.E.	± 0.8	± 0.5	± 0.1	± 0.5	± 0.8	± 0.5	± 0.1	± 0.5

Number of Tubers (Thousands per Acre)

L_1	22	157	42	221	61	81	19	161
L_2	26	144	45	215	58	80	9	147
L_3	29	117	31	177	55	83	13	151
S.E.	± 3.2	± 4.6	± 3.2	± 5.3	± 3.2	± 4.6	± 3.2	± 5.3

EXPERIMENT 2, 1960-61

Fig. 20 NUMBER AND WEIGHT OF TUBERS OF DIFFERENT GRADES AS INFLUENCED BY SROUT LENGTH



Again, in Arran Pilot, the lower yield and number of ware for L_1 was related to a higher yield and number of seeds and chats. In Majestic there was little difference in yield of seed between the sprout length levels. The maximum differences in yield and number of seed tubers between sprout length levels were 3.5 tons and 40 thousand per acre in Arran Pilot, whereas in Majestic they were negligible. The interaction of sprout-length levels with variety was highly significant. Figure 20 shows graphically the number and weight of tubers of different grades as influenced by different sprout length levels.

The Effects of Sprout-length and Chitting on the Yields and the Number of Tubers

The interaction between dates of chitting and sprout-length level was not significant for the total yields, but it was significant for the total number of tubers produced. Table 91 shows that the maximum differences in the number of tubers between any two dates of chitting were 17, 27 and 14 thousand tubers at short (L_1), medium (L_2) and long (L_3) sprout-length levels respectively. On average, no chitting gave a higher number of tubers per acre than chitting, which is evident from the same table under each sprout level, and this agrees with the results of Experiment 1.

TABLE 91

Experiment 2, 1960-61

The Influence of Chitting and Sprout-length on the Yield and Number of Different Grades of Tubers

Yield of Tubers (Tons per Acre)

Dates of Chitting	L_1				L_2				L_3			
	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total
November	9.7	11.1	0.5	21.3	12.4	9.6	0.4	22.4	11.2	9.1	0.5	20.8
December	11.4	9.6	0.5	21.5	9.8	11.7	0.6	22.1	10.1	8.6	0.5	19.2
January	9.5	11.9	0.7	22.1	10.6	10.1	0.5	21.2	11.1	9.5	0.3	20.9
February	12.3	10.1	0.5	22.9	12.1	8.9	0.4	21.4	11.6	8.7	0.5	20.8
No chitting	8.8	11.4	0.6	20.8	8.4	11.1	0.6	20.1	6.2	14.1	0.9	21.2
S.E.	±1.1	±0.7	±0.2	±1.4	±1.1	±0.7	±0.2	±1.4	±1.1	±0.7	±0.2	±1.4

Number of Tubers (Thousands per Acre)

Dates of Chitting	L_1 Ware	L_1 Seed	L_1 Chats	L_1 Total	L_2 Ware	L_2 Seed	L_2 Chats	L_2 Total	L_3 Ware	L_3 Seed	L_3 Chats	L_3 Total
November	37	127	34	198	46	104	28	178	44	103	25	172
December	46	110	27	183	40	133	25	198	36	95	27	158
January	35	130	35	200	39	105	33	177	43	104	14	161
February	48	109	26	183	44	106	21	171	44	98	24	166
No Chitting	38	127	35	195	34	136	35	205	27	157	50	234
S.E.	±4.0	±6.5	±4.5	±7.4	±4.0	±6.5	±4.5	±7.4	±4.0	±6.5	±4.5	±7.4

Most of this significant interaction must stem from the differences in the no sprouting treatments, which in fact were the same. This interaction must therefore be a chance effect.

The three factor interaction, i.e. sprout-length levels, variety and dates of chitting was not significant for the yield or number of tubers of any grade.

The Yield and Number of Tubers as Influenced by Dates of Chitting

Chitting at different dates did not give a significant difference in the total yield of tubers, or the yield of seed. However, there was a significant difference at the 5 per cent level for the total number of tubers, the yield and number of ware grade, the number of seed and the yield of chats. The results for yield and number of tubers with each grade are shown in Table 92 for all dates of chitting and variety. The significant differences due to different dates of chitting resulted from an increase in the number of tubers in unsprouted tubers as compared to any of the chitting treatments. Similarly the significant differences in the yield and number of ware tubers resulted from lower yields and number of ware from unsprouted tubers as compared to the unsprouted ones. A significant difference in the number of seed tubers may also be attributed to a much greater number of seed tubers from the unsprouted tubers.

TABLE 92

Experiment 2, 1960-61

The Influence of Chitting on the Yield and Number of Different Grades of Tubers

Yield of Tubers (Tons per Acre)

Dates of Chitting	Arran Pilot Ware	Seed	Chats	Total	Majestic Ware	Seed	Chats	Total
November	6.1	12.4	0.7	19.2	16.1	7.4	0.3	23.8
December	5.9	10.9	0.8	17.6	14.9	9.1	0.3	24.3
January	4.9	12.0	0.8	17.7	15.8	9.0	0.3	25.1
February	7.1	11.2	0.7	19.0	16.9	7.3	0.2	24.4
No Chitting	4.7	12.3	0.7	17.7	10.9	12.1	0.8	23.8
S.E.	±0.8	±1.6	±0.05	±0.6	±0.8	±1.6	±0.05	±0.6

Number of Tubers (Thousands per Acre)

November	27	147	42	216	58	76	16	150
December	25	134	40	199	56	92	12	160
January	21	139	39	199	57	88	14	159
February	30	138	36	204	61	71	10	142
No Chitting	22	153	38	213	44	128	37	209
S.E.	±2.8	±7.7	±3.8	±9.3	±2.8	±7.7	±3.8	±9.3

The effects of dates of chitting in this experiment were very similar to those found in Experiment 1. In other words, chitting from November resulted in the highest yield and number of tubers per acre in Arran Pilot and there was apparently not much difference in the yield and number of tubers from chitting at other dates. Also, the unsprouted tubers gave the highest number of tubers per acre in Majestic as in Experiment 1. Similarly, the yields and the number of different grades of tubers were affected as in Experiment 1 (Table 80). It may be said that these results are good corroboration of the findings in Experiment 1.

DISCUSSION

DISCUSSION

It is a well known fact that potatoes under ordinary conditions will not sprout for some time after they are dug. This period varies in different varieties. When a few tubers of a lot begin to sprout, it is only a matter of a few days until all will sprout. When the rest period is over, it requires low temperature ($40^{o}F$ or a little below) to keep the seed tubers dormant for a reasonable period. Some sprout suppressing chemicals are also effective in prolonging the dormant period. More eye-buds eventually produce sprouts on prolonging the dormancy of potato seed tubers by low temperature storage, or by the application of sprout suppressing chemicals. Arran Pilot, an early variety, has a shorter rest period than Majestic, which is an early-maincrop variety. In any event, once the sprouts begin to grow in Arran Pilot, in the period of a month or so, they grow to an undesirable size if the temperature is above $60^{o}F$ under subdued light conditions. Majestic on the other hand, maintains its slow rate of growth through the storage period under similar conditions.

As a basis for the discussion, some of the potato tuber's morphological characters will be first recalled. These tubers arise by the enlargement of the terminal end of under-ground stems. The eyes scattered over the tuber represent clusters of buds. In order to explain the bud clusters, it is necessary to assume that the potato tuber is a much branched stem and that each eye represents a lateral branch. Each eye would then contain a central or potential terminal bud, surrounded by lateral ones. In most stems the terminal bud seems to be stronger than the others, and develops into a more vigorous shoot. The greater vigour of the terminal shoot may be due to greater inherent strength of the terminal bud, or it may be because the terminal shoot inhibits the growth of the lateral ones. The latter view best suits the experimental requirements regarding the growth of buds on the potato tuber.

When all the eyes of a tuber are subjected to the same external conditions, the buds on the terminal or seed end will grow out first. The number of buds that will start depends upon the variety, size of the tuber, vigour of the terminal sprout and the date of sprouting. In this case Arran Pilot tended to develop more sprouts per seed tuber than Majestic, due to its inherent character. The dominant sprouts were usually noted to develop on the apical region of the seed tubers in both varieties. Bushnell (36), Toosey (175, 176) and Shutton (156) have shown that the yield and the proportion of different grades of tubers can be controlled largely by the number of sprouts per seed tuber. The results of the present investigation have shown that seed tubers trayed up early in the autumn (any time from October to December) developed one dominant sprout (or sometimes 2 to 3), usually on the apical region of the seed tubers. This phase of sprouting is called apical dominance, because the terminal sprout suppresses the growth of the lateral sprouts. Apical dominance is seldom absolute in the sense that it completely inhibits the growth of other buds. Other sprouts (5 to 15 in number) usually below 1.0 cm. in length, develop but show little growth and seldom grow to stems when the tubers are planted in the field. Sometimes under high temperature storage (over $65^{\circ}F$) sprouts below 0.5 cm. dry off.

When the seed tubers are trayed up in winter (any time from January to March) many sprouts develop within a week, and these are distributed all over the surface of the seed tubers. But the presence of terminal sprouts on the apical region and the central sprouts (one or two sprouts in the middle of each eye-bud) on the other regions of the seed tubers, inhibit the growth of the side sprouts. Storage at low temperature ($40^{\circ}F$ all the period) also brought the seed tubers to the multiple sprouting phase, but here also the terminal sprouts and the central sprouts on other eyes exhibited dominance over the other sprouts. These results are quite similar to those obtained by many authors (10, 36, 175). It is interesting to note that multiple sprouting during the storage period does not necessarily continue when they are planted in the field, because the sprouts on the middle or heel region seldom develop into growing stems. Only about 20-30 per cent of the sprouts grow into main-stems from the middle or heel regions of the seed tubers, while the rest come from the apical region. This shows that apical dominance is exhibited even after the seed tubers are planted in the field.

In this case, the work of Prunet on the development of the potato, which has been reviewed by Clark (40) should be mentioned. Studies of the composition of tubers before and after growth had ceased, led Prunet (141) to conclude that during the period of growth, the nutritive substances are uniformly distributed throughout the tuber, but after full size has been reached there is a movement of these substances toward the vicinity of the apical buds.

The high degree of apical dominance can be broken down by desprouting the seed tubers. The more the desprouting, the greater is the suppression of apical dominance. But, at the same time, a greater amount of food stored in the tuber is lost, and it was found in this work that under high temperature and dark storage condition, which caused the seed tubers to produce very long sprouts, the double desprouted seed tubers (mainly of Arran Pilot) seldom produced a third crop of sprouts. Such tubers developed small spindly sprouts which, when planted in the field, produced 5-10 small tubers, often without any foliage growth.

The phenomenon of apical dominance is difficult to explain. Diverse opinions on this subject have been given by several authors (see the review of literature). Certainly, the apical bud of the tuber is the apical bud of the stolon, and not only is it the largest bud on the tuber, but also it may have a better developed vascular system going from it to the base of the tuber, as suggested by Sadler (147). Thus, when the tuber is kept at a high temperature, the apical bud grows very rapidly, and prevents other buds from growing. When tubers are kept at a low temperature, the apical bud is not able to grow rapidly, and does not remove all the readily-available substrate, and therefore buds at other positions also grow. After a prolonged storage at low temperature, the apical bud again maintains a higher growth rate, but this could be because it is initially larger than the other buds. However, this is not the complete story, because after the sprouts have been removed by ethylene chlorohydrin or by desprouting (as reported by Sadler), the newly-formed sprouts in the apical position still have the greatest mean growth rate per sprout. Similarly, the buds at other positions maintain their relative growth relationships, but with greater growth rates.

With growth of the sprout, there is a concurrent disappearance of starch in the mother tuber in the region of the base of the sprout, and this is almost certainly accompanied by an increase in the concentration of soluble sugar and soluble nitrogen as reported by Headford (89). Sprouts developing in this position are therefore likely to have a larger supply of available substrate, and this may be the reason for increased growth. Headford has shown that growth of sprouts is closely dependent upon the supply of substrate.

Appleman (10) found that apical dominance could be overcome by excising the eyes, so that single eye pieces each produced a sprout. In tubers cut transversely in two, each piece gave rise to one sprout which inhibited the growth of other sprouts, suggesting that the apical dominance was broken down in that all the sprouts, when separated from the apical influence, were able to grow at similar rates and this conclusion was confirmed by Headford (89). Thus sprout growth is definitely a phenomenon in which the apical bud partially, if not completely, inhibits growth of the buds at other positions, and they, in their turn, inhibit the growth of their own lateral buds.

Gregory and Vale (78) postulated that apical dominance is correlated with the carbohydrate and nitrogen levels in the plant: at low levels of nitrogen the apical bud drains all the available substrate away, but at high levels there is competition between the various meristems. Auxin is of importance in controlling the development of the lateral vascular system; if it is present in large quantities, it may prevent the development of these vascular tissues and so deprive the lateral buds of nutrients.

The presence of chitted sprouts is a most important factor in the production of good stands and high yields. Plants from sprouted tubers usually emerge 10-15 days earlier than those of unsprouted seed tubers. Plants from the sprouted seed grow earlier, and the daily increase in stem length during the early stages of growth is increased by sprouting, the difference in growth rate becomes less marked later in the season. The dry matter production is also governed in a similar manner. Again, the date of sprouting did not apparently influence the rate of plant emergence and the rate of plant growth in our experiment, which is contrary to the works of many authors (36, 119, 120, 156) who have found that early sprouted seed tubers give earlier emergence, give more rapid plant growth, earlier tuber formation and mature earlier than those sprouted at later dates.

In the following section a relationship between the number of sprouts, number of main-stems, number of above-ground stems (main-stems + underground branches) and number of tubers, as affected by various chitting treatments, will be discussed. The sprouting behaviour of the two varieties was a little different in the 1960-61 experiments compared with the previous year. Sprouting at the successive dates of chitting did not show an increase in the number of dominant sprouts per seed tuber in Arran Pilot, whereas it did in Majestic, so that there was an interaction between dates of chitting and variety in the development of above-ground stems and tubers per hill. Apically dominant sprouted seed tubers produced more underground branches per main-stem due to the development of more nodes per dominant sprout as a result of longer chitting. The number of tubers per hill, on the other hand, depended on the number of main-stems per hill. For example, there were 2 to 3 apically dominant main-stems per hill in Arran Pilot (1960-61 Experiment) which gave more tubers per hill than those of Majestic which always gave one or a little over one main-stem per hill from chitting. Unsprouted seed tubers produced the greatest number of main-stems per hill, and on average, gave more tubers per hill than those of sprouted ones. On the other hand, the number of tubers per main-stem from plants of unsprouted tubers was less than that from those sprouted at any date, presumably because the main-stems from unsprouted tubers seldom produced underground branches. Earliness in chitting, resulted in tubers of larger size than late sprouting. Chitting at later dates, on the other hand, gave tubers of smaller size and hence a higher proportion of seed tubers than later sprouting. But this does not hold good for Arran Pilot in the Experiments of 1960-61, since more than one dominant sprout (or main-stem) developed in this variety, when set up for chitting in November. Also this early chitting developed more nodes per dominant sprout than late chitting, and possibly it may be the combined effect of early chitting, which developed more nodes per sprout, and a slightly higher number of main-stems per hill for this chitting date compared with later chitting (Table 43) that produced the greater number of tubers. Majestic under similar conditions increased the number of main-stems and tubers per hill at each successive date of chitting. The results with Majestic, however, agree with those of Bushnell (27), Hardenburg (86), Toosey (175, 176) and Shotton (156).

It is quite interesting to note that as the length of the chitting period increased, the number of main-stems per hill decreased in the variety Majestic, but very little effect was shown in Arran Pilot. This effect occurs because the earlier the seed tubers are taken out from cool storage, the more marked is the apical dominance. Where apical dominance is desired in chitted tubers of Arran Pilot, an early variety, such a transfer for chitting requires to be earlier than for Majestic.

Shotton (156) demonstrated that four week sprouting for this variety should be enough. He said if this can be achieved, the results will be of considerable practical value to growers, for the tubers which had the shortest sprouting period also had the shortest sprouts - 1.4" long from 1st. March sprouting, compared with 3.1" long from 1st. February sprouting. The shorter sprouts are far less likely to be damaged during mechanical planting, and less likely to become unmanageable if planting should have to be delayed.

The ultimate value of chitting must be determined by its effect on the yield of marketable size tubers. The crop from the experiment was sized into three grades - ware - over $2\frac{1}{4}$", seed - $2\frac{1}{4}$" - $1\frac{1}{4}$" and chats below $1\frac{1}{4}$". In the experiments, there was no significant increase in yield from sprouted seed as compared with unsprouted seed. It should be pointed out, however, that all treatments were allowed to reach maturity and that blight was not a complicatory factor. On average, unsprouted seed tubers gave a greater number of tubers than sprouted tubers in both varieties, and the differences were highly significant. However, seed of Arran Pilot chitted from November, gave a similar number of tubers to the unchitted seed. Since the number of tubers is inversely related to the size of the tubers, there was an increase in the yield as well as the number of seed sized tubers in favour of unsprouted seed. An increase in the proportion of seed sized tubers meant that a lower yield and number of ware grade tubers were produced by the unsprouted seed tubers. The amount of chats was associated with the quantity of seed tubers produced in the crop. In other words, there was a tendency for there to be more chats when there was a high yield of seed sized tubers.

Excluding the unsprouted treatments, chitting at different dates from November to February did not result in any marked differences in the total yield or number of tubers in either variety, though there was a trend for an increase in the total number of tubers of Majestic as the date of chitting became later, while there was a reversed trend in the variety Arran Pilot, the reasons for which have already been discussed.

The effect of producing different sprout length levels at the various dates of chitting was studied to see if sprout-length does affect the yield or number of tubers. Three sprout length levels namely, approximately 1.0 cm, 2.0 cm. and 3.0 cm.

and four dates of chitting (as in Experiment 1) were included in this investigation. Unfortunately, the sprout length levels were not controlled to the desired sizes (as described earlier) and the sprouts of Arran Pilot increased to 5-7 cm. and in Majestic to 1-3 cm. (Table 48) before planting. There was, in fact, little difference in length between each of the sprout length levels in each variety. However, since the seed tubers were shifted to cool storage in the barn at Boghall Farm at different dates to control the sprout length, the sprouts of different treatments became morphologically different. Tubers shifted first to low temperature gave a slightly higher number of nodes per dominant sprout (Table 49) which presumably resulted in more stolon-bearing underground branches (and hence tubers per hill) than those shifted at later dates. Although the increase in the total yield in favour of short sprout level was not significant in either variety, the differences in the total number of tubers and the yield and number of seed sized tubers were highly significant. The results are similar to those obtained by Heile (90) who worked on much smaller seed tubers (35-80 g. per set) than used in this experiment. A greater number of nodes per sprout in the "short" sprout treatment may have been due to a greater thickening of the sprouts at low temperature than at high temperature. At high temperature the sprout grows longer and the internodes are also longer. A short stubby sprout may thus produce more stolons and hence tubers.

Seed tubers stored at 40°F during 1959-60 were grouped into four lots and a short period (10 days) of heat treatment (65-70°F) was given to each of three lots in November, January, and in both November and January, to investigate the effect of heat exposure on the development of sprouts and on the subsequent crop, while the fourth lot was left untreated. This was based on the assumption that a change of temperature from low to high during the storage period might stimulate the seed tubers to make a sudden burst of producing numerous sprouts, i.e. might break the apical dominance. Although the number of sprouts per seed tuber increased according to the amount of heat treatment given to the seed tubers, the number of main-stems (sprouts growing to stems) was virtually the same as from the untreated tubers. There was, however, a slight reduction in the number of tubers per hill, when seed tubers of Arran Pilot were exposed to heat, while there was an increase in the number of tubers in Majestic under similar heat treatment. This suggests that varieties respond differently to the amount of heat given to the seed tubers, and this seems likely to be related to the speed of sprouting. The response of Arran Pilot to produce a greater number of tubers or seed sized tubers from storage at low temperature, is similar to the results obtained by Ehrondorfer (61) who reported that at low temperature, many eye-buds open and sprout. Muller-Thurgau (124) found, however, that if potato tubers were stored at temperatures below about 6°C (43°F) the content of sugar increased.

Presumably, an increase in the sugar content may be an important factor in increasing the number of sprouts at low temperature. Why Majestic did not respond similarly cannot be explained. Further work on this subject is essential before one could draw definite conclusions.

Seed tubers were also stored in a pit in 1959-60 to study the effect of desprouting, which often occurs during riddling before planting. The results showed that the removal of long etiolated sprouts at the time of riddling do cause an increase in the number of main-stems and tubers per hill, as compared to tubers which are planted with the long etiolated sprouts attached. The two varieties gave a similar response. One of the effects of sprout removal, on the subsequent development of the plant, was to delay plant emergence. Such a delay in early plant growth is due to the fact that removal of sprouts might have caused a loss of growth substances as evidenced by McCubbin (119). The tubers have also to produce new sprouts, before plant emergence can occur.

Desprouting did not affect the total yield significantly. However, the increase in the total number of tubers, in the yield and the number of seed tubers in favour of desprouting was significant at the 5 per cent level. This increase in the total number of tubers, and the number of seed sized tubers was associated with a corresponding reduction in the number of ware sized tubers. By planting time Majestic had produced only small sprouts in the pit, which were not removed.

A comparison was made between the effects of storage in the pit and storage at low temperature in the refrigeration room ($40^{\circ}F$) on the subsequent development of the plants and tubers. Both the experiments, on small scale (Sub-Experiment 1) and large scale (Experiment 1) showed that storage at low temperature gave a higher number of main-stems (also above-ground stems) and tubers. The increase in the total number of tubers (i.e. ware, seed and chats) as well as the number of seed sized tubers in favour of low temperature storage was highly significant. It should be pointed out here again that seed tubers stored in the pit were slightly (14.5 per cent) heavier in weight than those stored at low temperature. On the basis of work done by several workers (17, 23, 144, 170, 184) large seed tubers should give more tubers per hill than small seed tubers, if they are stored under similar storage conditions. The tendency here for the smaller tubers stored at low temperature to yield more tubers than large seed tubers stored in the pit, strongly suggests that the effect of storage at low temperature compared with pit-storage was a real one.

Growers ordinarily do not think in terms of plants per hill, but are well aware that the distance between the hills and the size of the seed tubers control the yield and grade of tubers. The results of the present experiments have shown that in each of the two grades, seed and chats, the yield from close planting (9") was considerably larger than that from wide spacing (18") in each year. The total yield and number of tubers was also significantly greater at 9" spacing than 18" spacing. The yield of ware grade tubers was greatest at the wide spacing. Roughly speaking, 9" spacing produced, on the average, about 1.3 times as many tubers as did 18" spacing in the 1960 experiment and about 1.5 times in the 1961 crop, while the corresponding ratios for seed sized tubers in 1960 and 1961 were 1.4 and 1.6 times respectively. On the other hand, the yield and number of tubers per hill was much greater at wide spacing than close spacing. These results agree with those obtained by several authors (17, 39, 41).

The experiments of 1960 and 1961, although showing quite different total yields, gave practically the same difference in favour of close planting namely nil and 0.8 tons per acre in Arran Pilot and 2.9 and 2.5 tons per acre in Majestic respectively. The effect of an increase in spacing is to reduce the overall plant density and competition between plants, and thus increase the size of the tubers. The epxeriments in each year showed that the use of a very wide spacing between the hills did not remove the effects of plant competition within them. A hill with many main-stems, still gave a high number of small seed tubers (seeds and chats) than the one with fewer main-stems even at wide spacing. On the other hand, a hill containing only a few main-stems tended to produce large seed tubers at the same spacing. It would, therefore, appear that spacing must be adapted, as suggested by Bushnell (38) to the expected plant density within the hill, which is usually controlled by the number of sprouts per seed tuber, the size of the seed and the variety. When tubers with one sprout are planted, allowance must still be made for the greater size of the plants produced by large seed.

It has already been shown that both spacing and seed size have an influence upon the size of the individual tubers produced. In the case of spacing, it is not difficult to understand why a wider spacing should increase the size of individual tubers, for competition is lessened, and individual plants receive a greater supply of nutrients and moisture. As regards size of seed, the influence upon yield and size of produce is not so readily explained. It is obvious that the problem must be an anatomical or physiological one as shown by Bates (17). In connection with this question, one suggestion offered is that the amount of food material in the parent tuber is an influencing factor (150), in that the larger the seed tuber the greater the initial food supply to the growing point. It has been shown by Denny (48) that the amputation of the parent tubers at varying stages of the growth of potato plants, reduces the yield if amputation takes place before the shoots are 10" high. After the plants have reached that height, the presence of the rotting seed tubers appears to be detrimental, in that it exerts a toxic influence upon the growing plant.

While large seed tubers obviously possess a greater store of food material than small ones, they also possess more sprouts than small ones, and consequently more shoots to utilize this food supply. On the other hand, Wakankar (184) reported that with single eyed seed pieces the number of tubers produced per hill did not increase with size of seed piece. This again indicates that the amount of stored food is of secondary importance.

If tubers are planted at close or wide spacing, it is reasonable to assume that a tuber possessing a larger number of viable sprouts will give rise to a greater condition of over-crowding than will the tuber with fewer sprouts. The result of this crowded state would be a larger number of tubers in the produce yielded, these being small in size in comparison with the tubers from parent setts with fewer sprouts.

Yields were not significantly different due to large and small seed tubers. On the other hand, large seed produced 14 and 29 thousand tubers per acre more than small seed in Arran Pilot and Majestic respectively, a difference which is significant at the 5 per cent level. The results showed that the yield of ware from small seed was significantly greater than that from large seed, but the difference in the number of ware tubers produced by small seed tubers, was due to the development of a smaller number of main-stems, which resulted in fewer tubers per hill than from large seed, thus resulting in the average size of tuber being larger.

The interaction of seed size with spacing was non-significant. In other words, the response of large and small seed tubers, on average, was similar at both spacing.

It can be concluded that size of seed tubers influences yield and grade of produce in that it controls the number of main-stems and above-ground stems in the hill, and thus controls the intensity of competition. In other words, spacing controls the intensity of competition between the hills, while size of seed controls the intensity of competition within the hill.

Application of Sprouting to Farm Practices

Although the present study showed that the yield and the number of different grades of tubers are governed to a great extent by the number of sprouts, it is questionable whether the seed grower in the Edinburgh area should follow a sprouting technique to control the number of sprouts on the seed tubers, and thereby increase the proportion of seed tubers in the produce. The results of our experiments showed that the sprouted and unsprouted seed tubers gave similar yields, but the latter gave a significantly greater number of tubers and yield and number of seed sized tubers. Therefore, it can be said that a seed grower should aim to keep the seed tubers dormant for a longer period in order to induce more main-stems per hill, which will result in more tubers per hill.

However, the process of sprouting the seed may be regarded as a meansof harvesting a crop earlier, and thus escaping a possible outbreak of Late Blight.

CONCLUSIONS

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From the results, and from observations made in the field, it is possible to form a picture of the after-effects of various storage conditions, and the following conclusions are derived:

1. Low temperature storage ($40^{o}F$), and TCNB application can be used successfully to prolong the dormant period. Crops from seed stored at either conditions were similar in growth and yield of tubers of all grades.

2. Temperature and light are the most important controlling factors in the growth of sprouts, a change in either of these factors can suddenly change the growth of sprouts. High temperature in bright light gives reasonably short sprouts, while high temperature in darkness causes long etiolated sprouts.

3. The time at which chitting takes place, controls the number of sprouts per seed tuber. Seed tubers, when chitted immediately after lifting produce one (or sometimes 2 to 3) dominant sprout, usually on the apical region (apical dominance phase). When they are chitted at later dates, apical dominance gradually disappears and the number of sprouts per seed tuber increases (multiple sprouting phase).

4. There was no evidence that a short period of heat treatment ($65-70^{o}F$ for 10 days) during the storage period of seed tubers, did anything to break apical dominance.

5. Tubers with one sprout produce fewer tubers per hill than those with multiple sprouts, and those unsprouted, but result in a greater number of tubers per main-stem presumably due to the development of more nodes per dominant sprout and also to less competition among the tubers for plant food.

6. There was no evidence that there is any yield advantage from sprouted seed as compared with unsprouted seed, provided plants from both are allowed to reach maturity. The results do suggest, however, that unsprouted seed produce a crop with a larger number of tubers than sprouted seed. From this there seems to be considerable merit in planting unsprouted seed tubers where a seed crop is desired. It should also be stressed that early planting of unsprouted seed is desirable.

7. Plants from sprouted tubers emerge, flower, and tuberize about 10-15 days earlier than those stored at low temperature or treated with TCNB for the whole storage period.

8. Desprouting seed tubers of the variety Arran Pilot results in a crop with a significantly higher number of tubers. With this variety, therefore, there would seem to be some advantage, for seed potatoes, in planting unsprouted tubers which have lost sprouts during the riddling process, before planting

9. There was some evidence that seed tubers kept under chitting conditions (60-65°F) for a longer period (thus producing longer sprouts) produced plants with fewer tubers than seed chitted at the same time, but transferred to cool conditions ($\sim$ 40°F) earlier (when sprouts 1 cm. long). Further corroboration of this is required.

10. In all the comparisons the number of main-stems per hill was directly proportional to the number of tubers produced per hill, but the number of main-stems per hill was inversely proportional to the number of tubers per main-stem, i.e. a hill with fewer main-stems produced more tubers per main-stem than a hill with more main-stems.

11. The effect of large seed and close spacing in producing a larger population of main-stems and tubers per acre was corroborated in this work. The yield and the number of seed sized tubers also increased significantly, while there was a decrease in the yield and number of ware-sized tubers.

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BIBLIOGRAPHY

BIBLIOGRAPHY

1. Aicher, L.C. (1920). Experiments in the size of seed piece and other factors in the production of potatoes under irrigation in South Idaho. Idaho Agr. Expt. Sta. Bul.121.

2. Allison, R.M. and Driver, C.M. (1953). The effect of variety, storage, and locality on the ascorbic acid content of the potato tuber. J. Sci. Agric., 4: 386.

3. Anon (1908). Field Experiments. Jour. Dept. Agr. and Tech. Instr. Ireland 8: 296-97.

4. ------- (1949). The protection of stored seed potatoes. World crops. 1: 63-65.

5. -------- (1957). Sprouting seed potatoes in artificial light. Ministry of Agriculture, Fisheries and Food Publication.

6. ------- (1958). Report on the survey of main-crop potatoes. Potato Marketing Board, Rothamsted Experiment Station, National Institute of Agricultural Engineering.

7. Appleman, C.O. (1914). Biochemical and Physiological study of the rest period in the tubers of Solanum tuberosum. Md. Agr. Expt. Sta. Bul. No. 183.

8. ------- (1918). Special growth promoting substances and correlation. Science, 48: 1319.

9. ------- (1918). Physiological basis for the preparation of potatoes for seed. Md. Agric. Expt. Sta. Bul. 212.

10. ------- (1924). Apical dominance in potatoes as an index of seed value. Md. Agric. Expt. Sta. Bul. 265.

11. Arthur, J.C. (1892). The Potato: Relation of the number of eyes on the seed tuber to the product. Purdue Agric. Expt. Sta. Bul. No. 42.

12. Barker, J. (1932). Temperature and the metabolic balance in the potato. Dept. Sci. Industr. Res., Lond., Rep. Food Invest. Bd. for 1931, p. 86.

13. ------- (1937). The effect of temperature of storage on the sprouting of potatoes. Dept. Sci. Industr. Res., Lond., Food Invest. Bd. for 1936, p. 179.

14. ------- (1938). The effect of temperature history on the sensitivity of the sugar/starch balancing system in potatoes. Dept. Sci. Industr. Res., Lond., Food Invest. Bd. for 1938, p. 193.

15. ------- and Mapson, L. W. (1950). The ascorbic acid content of potato tubers. II. The influence of the temperature of storage. New Phytol. 49: 283.

16. Bartlett, M.S. (1937). Supp. J.R. Statist. Soc. V. 4, p. 164.

17. Bates, G.H. (1935). A study of the factors influencing size of potatoes. J. Agr. Sci. 25: 297-313.

18. Beilby, O.J. (1952). Regional trades in Scottish Agricultural production. Scot. J. Agric. 32: 141.

19. Black, C.A. (1957). Soil-Plant Relationships. John Wiley and Sons, Inc., N.Y.

20. Bonner, J. and Bandurski, R.S. (1952). Studies of the physiology, pharmacology, and biochemistry of the auxins. Ann. Rev. Pl. Physiol. 3: 59-86.

21. Boswell, V.R. (1931). Apical dominance in the tuber of Jerusalem Artichoke (Helianthus tuberosum L.) Proc. Am. Soc. Hort. Sci. 28: 301-304.

22.------- (1931). Size of seed piece and sprout removal in relation to sprout formation on Jerusalem Artichoke tubers. Proc. Am. Soc. Hort. Sci. 28: 291-96.

23. Boyd, D.A. (1954). The effect of seed rate on the yield of potatoes. J. Agr. Sci. 44: 465-76.

24. Brown, H.D. (1928). An interesting effect of green-sprouting upon the value of seed pieces from the apical and basal ends of potatoes. Proc. Amer. Soc. Hort. Sci. 101: 103.

25. Brown, W. (1947). Experiments on the effects of chlorinated nitrobenzenes on the sprouting of potato tubers. Ann. Appl. Biol. 34: 422.

26. ------- and Mellor, H.C. (1952). Anit-sprouting compositions. U.S.P. 2, 615-801, Oct. 28. Chem. Abstr., 1953, 47, 2927h.

27.------- (1954). Effect of tetrachloronitrobenzene on the sprouting and cropping of potato tubers. Ann. Appl. Biol. 41: 435-447.

28. Burton, W.G. (1948). The Potato: London. Chapman and Hall, Ltd.

29. ------- (1952). Physiological effects of the volatile products of respiring potatoes. Nature, Lond., 169: 117.

30.-------- (1952). Studies on the dormancy and sprouting of potatoes. III. The effect upon sprouting of volatile metabolic products other than carbondioxide. New Phytol. 51: 154.

31.-------- (1953). Enzyme studies on dormant and active potato tubers. Physiol. Plant. 6: 169.

32.-------- (1956). Observations on the growth substances in ether extracts of the potato tuber. Physiol. Plant., 9: 567.

33.-------- (1956). Suppression of the sprouting of potatoes by the vapours of alcohol. Nature, Lond., 178: 218.

34.-------- (1957). The dormancy and sprouting of potatoes. Food Science Abstracts. 29: 1-12.

35. Bushnell, J. (1927). Storage of seed potatoes. Bi-monthly Bul., Ohio Agr. Expt. Sta. 12: 142-48.

36.-------- (1929). The normal multiple sprouting of seed potatoes. Ohio Agr. Expt. Sta. Bul. No. 430.

37.-------- (1942). Effects of number of plants per hill on the yield of potatoes in Ohio. Am. Pot. J. 19: 119-23.

38. ------- (1942b). The age of maximum reproduction vigour in Irish Cobbler seed potatoes. Am. Pot. J. 19: 124-129.

39. Chucks, J. A.; Hawkins, A.; Brown, B.E.; and Steinmetz, F.H. (1945). Size of whole and cut seed and spacing in relation to potato yields. Maine Agr. Expt. Sta. Bul. 439.

40. Clark, C.F. (1921). Development of tubers in the potato. U.S.D.A. Bul. No. 958.

41. Claypool, L.L. and Morris, O.M. (1931). Some response of potato plants to spacing and thinning. Proc. Am. Soc. Hort. Sci. 28: 253-56.

42. Cooper, M. (1914). Practical cold storage, 2nd. ed. 1914: 503.

43. Cunningham, H.S. (1953). A histological study of the influence of sprout inhibitors on Fusarium infection of potato tubers. Phytopathol. 43: 95-98.

44. Dadd, C.V. (1960). Potato Sprouting Conference - Introduction and review of present position.*

45. Davidson, B.A. (1934). Potato growing for seed purposes. Dublin, Stationery Office (Dept. of Agr.) p. 10.

46. Denny, F.E. (1926). Hastening the sprouting of dormant potato tubers. Am. J. Bot. 13: 118. Second report on the use of chemicals for hastening the sprouting of dormant potato tubers. Am. J. Bot. 13: 386.

47.-------- (1926). Effect of thiourea upon bud inhibition and apical dominance of potato. Contr. Boyce. Thomp. Inst. 1: 154-67.

48. ------- (1929). Role of mother tuber in growth of potato plants. Bot. Gaz. 87: 157-194.

49. ------- (1942). The use of methyl ester of alpha-napthaleneacetic acid for inhibiting sprouting of potato tubers, and an estimate of the amount of chemical retained by tubers. Contr. Boyce Thomp. Inst. 12: 387.

---

* Papers read at N.A.A.S. (Eastern Region) Conference on Potato Sprouting, Cambridge, December, 1960.

50.-------; Guthrie, J.D. and Thornton, N.C. (1942). Effect of the vapour of the methyl ester - of alpha-napthaleneacetic acid on the sprouting and the sugar content of potato tubers. Contr. Boyce. Thomp. Inst. 12: 253.

51. Dittweiler, C. (1952). Zussamenhange zwischen Austreiben und Atmung bei der Kartoffelknolle I. Die Hemmung des Austreibens durch Fermentinhibitoren, insbesondere Urethane. Planta, 41: 214.

52. Doncaster, J.P. and Gregory, P.H. (1948). The spread of virus diseases in the potato crop. Agric. Res. Coun., Lond., Rep. Ser. No. 7.

53. Dostal, R. (1942). Über das Frühtreiben der Fliederzweige (Syringa Vulgaris) und Kartoffelknollen (Solanum tuberosum.) und die hormonale Deutung dafür. Gartenbauwiss., 16: 195.

54. Downie, W.A. (1949). The prevention of sprouting in stored potatoes. J. Dept. Agr. Vict. 47: 301-305.

55. ------- (1950). Prevention of sprouting in stored potatoes. Further studies. J. Dept. Agr. Vict. 48: 301-306.

56. ------- (1952). Maintenance of quality in stored table potatoes. J. Dept. Agr. Vict. 50: 61.

57. Driver, C.M. and Hawkes, J.G. (1943). Photoperiodism in the potato. I. General. (C.M. Driver). II. The photoperiodic reactions of some Southern American potatoes. (J. G. Hawkes) Imp. Bur. Plant Breed. Genet. techn. comm.

58. Driver, C.M. (1957). The effect of certain chemicals upon sprouting of potato tubers. New Zealand J. Sci. and Tech. 38A: 887-97.

59. Dyke, G.V. (1956) The effect of date of planting on the yield of potatoes. J. Agric. Sci. 47: 122-128.

60. Eastman, P.J. and Libby, W.C. (1947). Greensprouting and thiourea treatment. Maine Agr. Expt. Sta. Bul. 460 p. 53.

61. Ehrondorfer, K. (1955). Comparative trials on chitting potatoes in darkness and light. Bodenkultur, 8: 168-181.

62. Ellison, J.H. (1952). Inhibition of potato sprouting by 2, 3, 5, 6 - tetrachloronitrobenzene and methyl ester of alpha-napthaleneacetic acid. Am. Pot. J. 29: 176-81.

63.--------- and Cunningham, H.S. (1953). Effect of sprout inhibitors on the incidence of Fusarium dry rot and sprouting of potato tubers. Am. Pot. J. 30: 10-14.

64. Elmer, O.H. (1932). Growth inhibition of potato sprouts by the volatile products of apples. Science 75: 193.

65.------- (1936). Growth inhibition in the potato caused by a gas emanated from apples. J. Agr. Res. 52: 609.

66. Emilsson, B. (1949). Studies on the rest period in the potato tuber. Acta. Agric. Suec. 3: 191.

67.-------; Lillieroth, C.G. and Nilsson, R. (1949). Anvandning av gronongshammende medel vid lagring av matpotatis. 2. Forsok under lagringssasongern 1948-1949. J. Royal Swedish Acad. Agr. 88. 487-506.

68.------- ;Lillieroth, C.G. and Nilsson, R. (1951). J. Royal Swe- Swedish Acad. Agr. 90:421-429.

69. Findlay, D.H. and Sykes, E.T. (1938). Influence of size of seed and spacing on the yield of King Edward VII. Emp. J. Expt. Agr. 6: 253-61.

70. Findlay, W.M. (1946). Notes from Craibstone. Potatoes 1945. Scot. Farmer, 16 Feb.

71. Finden, H. (1955). Effect of several chemicals on sprouting of stored tablestock potatoes. Am. Pot. J. 32: 159.

72. Fischnich, O. (1954). Exertion of influence on the sprouting of potatoes and the practical value of such procedure for breeder and grower. Landbouwk. Tijdschr., Wageningen, 66: (8), 566.

73. Gausman, H.W. and Dungan, G.H. (1954). Some effects of certain plant growth substances on maize. Bot. Gaz. 116: 29-40.

74. Germann, O. (1947). The influence of sprout removal on productivity of seed potatoes. Landbauforsch. Völkenrode 7: No. 1. 19-21.

75. --------- (1960). The effect of removing sprouts once or several times on the development and yield of potatoes. Z. Acker - u. PflBau 1960, 111, No. 1: 73-91.

76. Glasscock, H.H. (1949). Prevention of sprouting in potato clamps. The Gardener's Chron. 125: 54-55.

77. Greig. R. B. (1906). The sprouting of seed potatoes. Aberdeen and N. of Scotland Coll. of Agr. Bul. 3:9.

78. Gregory, F. G. and Vale, J.A. (1957). A re-assessment of the problem of apical dominance. Symp. Soc. Expt. Biol. 11, 1.

79. Guthrie, J. D.(1938). Effect of ethylene thiocynohydrin, ethyl carbylamine and indoleacetic acid on the sprouting of potato tubers. Contr. Boyce. Thomp. Inst. 9: 265.

80. ------- (1939). Control of bud growth and initiation of roots at the cut surfaces of potato tubers with growth-regulating substances. Contr. Boyce. Thomp. Inst. 11: 29.

81. ------- (1940). Rate of glutathione in the breaking of rest period of buds by ethylene chlorohydrin. Contr. Boyce. Thomp. Inst. 11: 261.

82. ------- (1941). A preparation from yeast that is active in breaking the rest period of buds. Contr. Boyce. Thomp. Inst. 12: 195.

83. Hanlan, L.H. (1929). Sprouted versus unsprouted potatoes. Seasonable Hints from the Dominion Expt. Farm No. 43.

84. Hardenburg, E.V. (1922). A study by the crop survey method, of factors influencing the yield of potatoes. Cornell Univ. Agr. Expt. Sta. Mem. 57: 1208.

85.---------- (1928). Some effects of greensprouting seed potatoes. Proc. Am. Soc. Hort. Sci. 25:91-96.

25: 91-96.

86.---------- (1935). Greensprouting seed potatoes. Cornell Univ. Agr. Expt. Sta. N.Y. Bul. 632.

87. Hartman, J. D.(1934). Studies of the effects of storage temperature on the propagation value of potato tubers. Cornell Univ. Agr. Expt. Sta. Mem. 168.

88. Hayward, H. E.(1938). The structure of economic plants. The Macmillan Company, N.Y.

89. Headford, D.W.R. (1961). Sprout development and subsequent plant growth. Europ. Pot. J. 5; (1), 14-22.

90. Heile, F. J.H. Van and Vervelde, G.J. (1954). Het belang van gelizkmatig pootgoed bij de aardappelteelt (The importance of uniformity in seed potatoes) Landbouwk. Tijdschr., Wageningen 1954, 66. No. 10, 686-94.

91. Hemberg, T. (1947). Studies of auxin and growth inhibiting substances in the potato tuber and their significance with regard to its rest period. Acta. Hort. Berg., 14: 133.

92. -----------(1949). Significance of growth inhibiting substances and auxins for the rest period of the potato tuber. Physiol. Plant., 2: 24.

93. -----------(1950). The effect of glutathione on the growth-inhibiting substances in resting potato tubers, Physiol. Plant., 3: 17.

94. -----------(1951). Establishment of acid growth-inhibiting substances in plant extracts containing auxins by means of Avena test. Physiol. Plant. 4: 437.

95. -----------(1952). The significance of the acid growth-inhiting substances for the rest period of the potato tuber. Physiol. Plant. 5: 115.

96. ---------- (1954). Studies on the occurrence of free and bound auxins and growth-inhibiting substances in the potato tuber. Physiol. Plant. 7: 312.

97. Hofstra, D. (1956) Het gebruik van kiemremmingsmiddelen. Pub. Stichting voor Aardappelbewaring, ser. A. No. 111.

98. Hollinrake, H. (1960). Design studies for new buildings.*

99. Huelin, F.E. (1933). Effects of ethylene and apple vapours on the sprouting of potatoes. Dept. Sci. Industr. Res., Lond., Rep. Food. Invest. Bd. for 1932, p. 51.

100. Hurst. R.R. and Maclaren, H.L (1934). Some observations on the sprouting habits of potato tubers exposed to low temperature. Am. Pot. J. 11: 123-27.

101. Jehle, R.A. and Walker, E.A. (1937). Storage temperature studied with Irish Cobbler seed potatoes. Am. Pot. J. 14: 394-410.

102. Julen, G. (1941). The potato as a source of vitamin C Lantbrukshögsk. Ann., 9: 294.

103. ----------(1944). Vitamin C metabolism in potatoes. Lantbrukshögsk. Ann., 12: 131

104. Kawakami, K. (1952). Physiological aspects of potato seed tubers. Bull. Lab. Plant Breeding, Hyogo Agric. Coll. Japan.

105. Kennedy, E.J. and Smith, O. (1951). Response of the potato to field application of maleic hydrazide. Am. Pot. J. 28: 701.

* Papers read at N.A.A.S. (Eastern Region) Conference on Potato Sprouting, Cambridge, December, 1960.

106. Krijthe, N. (1946). De invloed van de bewaring der aardappelknollen op den bouw van de knoppen en op de ontwikkeling tot volwassen plant. 1. Meded. Landbouwhoogesch., Wageningen, 47: (6).

107.--------- (1948). Over de invloed van temperatur en light tijdens de bewaring van pootaardappilen opde oogst van eerstelingen. Laboratoium voor plantenphysiologisch onderzoek Wageningen Medeling Nr. 73.

108. ---------- (1955). Observations on the formation and growth of tubers on the potato plant. Netherland J. Agric. Sci. 3: 291-304.

109.---------- (1958). Changes in the germinating power of potatoes from lifting time onwards. Europ. Pot. J. 1: 69-72.

110. Leclurg, E.L. (1943). Effect of whole and cut seed on stand and yield of Irish potatoes. Lousiana Agr. Expt. Sta. Bul. 371.

111. Luckwill, L.C. (1947). A further experiment on the use of growth substances to inhibit the sprouting of stored potatoes. Rep. Agric. Hort. Res. Sta. Long Ashton, Bristol. p. 137.

112.----------- (1948). The suppression of sprouting in ware potatoes. Rep. Agric. Hort. Res. Sta. Long Ashton, Bristol. p. 124.

113. Marshall, E.R. and Smith, O. (1951). Maleic hydrazide as a sprout inhibitor for potatoes. Bot. Gaz., 112: 329.

114. Marth, P.C. and Schultz, E.S. (1950). Effect of growth regulators on sprouting of stored table stock potatoes and on waste piles for control of disease. Am. Pot. J. 27: 23.

115.-----------(1954). A new sprout inhibitor for potato tubers. Am. Pot. J. 29: 268.

116. Martin, W.H.; Peacock, W. and Lombard, P.M. (1925). Northern vs. Southern potatoes as seed. Proc. Pot. Ass. Amer. 12: 23.

117. Mathur, P.B. and Srivastava, H.C. (1954). Effect of terpinol in inhibiting the sprouting of potato tubers during storage. Bull. Centr. Food Tech. Res. Inst., Mysore, 3: 271.

118. McCallum, W.B. (1909 . Rep. Arizona Agric. Expt. Sta. p. 584.

119. McCubbin, E.N. (1941). Influence of sprouts on plant emergence, growth, tuber development and yield of potatoes. Am. Pot. J. 18: 163-74.

120. Megaw, W.J. and Bankhead, J. (1938). Test of planting different sizes and types of seed potatoes. J. Min. Agr. N. Ireland, 6.

121. Michener, H.D. (1942). Dormancy and apical dominance in potato tubers. Am. J. Bot. 29: 558.

122. Miller, L.P. (1931). The influence of sulphur compounds in breaking the dormancy of potato tubers. Preliminary report. Contr. Boyce. Thomp. Inst. 3: 309.

123. Mooi, J.C. (1949). Toepassing van Fusarex bij bewaring van aardappalen in kuilen. Landbouwk. Tijdschr. 61: 628-637.

124. Muller-Thurgau, H. (1882). Über Zuckeranhäufung in pfanzentheilen in Folge niedriger Temperatur. Landw. Jb., 11: 751.

125. Mumford, H.W. (1927). Three temperatures for seed potatoes storage studied. Illinois Agr. Expt. Sta. Annual Report. p. 67.

126. N. Scotland Coll. Agric., Aberdeen. (1928). Notes from Craibstone. Scot. J. Agric. 11: 82.

127.------------(1929). Notes from Craibstone. Scot. J. Agric. 12: 69-70.

128.------------(1930). Notes from Craibstone. Scot. J. Agric. 13: 79-80.

129.------------(1931). Notes from Craibstone. Scot. J. Agric. 14: 82-83.

130.-------------(1932). Notes from Craibstone. Scot. J. Agric. 15: 79-80.

131.-------------(1933). Notes from Craibstone. Scot. J. Agric. 16: 87-89.

132.-------------(1934). Notes from Craibstone. Scot. J. Agric. 17: 85-87.

133.-------------(1935). Notes from Craibstone. Scot. J. Agric. 18: 64-66.

134.-------------(1936). Notes from Craibstone. Scot. J. Agric. 19: 64-65.

135.-------------(1937). Notes from Craibstone. Scot. J. Agric. 20: 57-63.

136.--------------(1938). Notes from Craibstone. Scot. J. Agric. 21: 169-171.

137.--------------(1939). Notes from Craibstone. Scot. J. Agric. 22: 177-179.

138. Paterson, D.R.; Wittwer, S.H.; Weller, L.E. and Sell, H.M. (1952). The effect of pre-harvest foliar sprays of maleic hydrazide on sprout inhibition and storage quality of potatoes. Plant physiol. 27: 135-142.

139. Peacock, W.M. and Wright, R.C. (1928). Influence of different storage temperatures on dormant seed potatoes. Proc. Pot. Assoc. of Amer., 1927., p. 126-130.

140. Perlasca, G. (1956). Chemical control of sprouting in white potatoes. Am. Pot. J. 33: 113-33.

141. Prunet, A. (1893). Recherches physiologiques sur les tubercules de la pomme de terre. In Rev. Gen. Bot. 5, No. 50, p. 49-64.

142. Puscharew, V. (1933). The potato seed tuber greensprouting under the short day conditions. Am. Pot. J. 11: 303.

143. Phodes, A.W.; Sexton, A.; Spencer, L.G. and Templeman, W.G. (1950). Use of iso-phenylcarbamate to reduce sprouting of potato tubers during storage. Research, Lond., 3: 189.

144. Rosa, J. T. (1922). Seed studies with Irish Potatoes. Mo. Agr. Expt. Sta. Bul. 191: 20-32.

145. ------------ (1923). Abbreviation of the dormant period in potato tubers. Proc. Amer. Soc. Hort. Sci. 20: 180.

146.-------------(1928). Relation of tuber maturity and storage factors to potato dormancy. Hilgardia 3: 99.

147. Sadler, E.M.(1961). Factors influencing the development of sprouts of the potato. Ph. D. Thesis. University of Nottingham.

148. Salaman, R.N.(1921). The influence of size and character of seed on the yield of potatoes. J. Min. Agr. 28: 43-48.

149.-------------(1922). The influence of size and character of seed on the yield of potatoes. J. Agr. Sci. 12: 182-196.

150.-------------(1923). The determination of the best method of estimating potato yields together with a further note on the influence of size of set on the character and yield of the potato. III. J. Agr. Sci. 13: 361-89.

151. Schippers, P.A. (1956). De invloed van de temperatur of de duurvan de rust periode. Pub. Stichting voor Aardappelbewaring, Ser. A, No. 108.

152. Schroven, D.A. van (1956). On the physiology of tuber formation in potatoes. I. Premature tuber formation. Plant and Soil. 8: 49.

153.-------------(1956). On the physiology of tuber formation. II. Influence of some organic compounds on tuber and sprout formation of potatoes aseptically grown in the dark. Plant and Soil. 8: 56.

154.-------------(1956). On the physiology of tuber formation. III. Influence of growth substances (phytohormones) on tuber and sprout formation of potatoes aseptically grown in the dark. Plant and Soil.8: 75.

155. Schulze, W. (1952). Der Einfluss der Lagertemperatur auf das Pflanzgut and die darau erwachsene Kartoffelstande. Landbauforschung Völkenrode, H.4, S. 80-82.

156. Shotton, F.E.(1961). Potato sprouting experiments at Terrington. Agriculture 68: 306-8.

157. Singh, B.N. and Wakankar, S.M. (1943). Effect of spacing and seed size on yield of potatoes. J. Am. Soc. Agron., 35: 613-616.

158. Smith, O. (1937). Influence of storage temperature and humidity on seed value of potatoes. Am. Pot. J. 14: 372-73.

159.------------; Hommel, R.F. and Kelley, W.C. (1943). Relation of rate and placement of fertilizer, variety, seed spacing and size of seed piece to yield of potatoes. Am. Pot. J. 20. 267-277.

160. Snell, K. (1932). Die Bechleunigung der Keimung bei der Kartoffelknolle. Ber. dtsch. Bot. Ges. 50A, 146.

161. Snyder, W.E. (1949). Some response of plants to 2,3,5- triidobenzoic acid. Pl. Physiol. 24: 195-206.

162. Steinbaur, G.P. (1946). Seed stock practices. Maine Agr. Expt. Sta. Bul. 442: 164-66.

163. Stewart, F.C.(1920). Experiments on the spacing of potato plants. N.Y. Agr. Expt. Sta. Bul. No. 474.

164. Stuart, W.; Lombard, P.M.; Vosbury, M.C., Corder, G.; Edmundson, W.C.; Clark, C.F. and Dewey, G.W. (1924). Size of potato sets, comparison of whole and cut seed. U.S. Dept. Agr. Bul. 1248.

165.-------------(1927). Source, character, and treatment of potato sets. U.S.D.A. Tech. Bul. 5.

166.-------------(1929). Comparative influence of different storage temperatures on weight losses and vitality of seed potatoes. U.S.D.A. Tech. Bul.117.

167.-------------(1937). Potato storage and shrinkage. The Potato. J. B. Lippincott. Company, N.Y. p. 210.

168. Stuivenberg, J.H.M. van and Veldstra, H. (1942). De practische toepassing van remming der spruitvorming bij aardappelen door behandling met groeistoffen in dampvorm. Landbouwk. Tijdschr.; Grav., 54, 611.

169. Taylor, C.E. and McDermott, N. (1959). The influence of pre-planting treatment of tubers on the growth and yield of two varieties of potato. Europ. Pot. J. 2, (4), 272.

170. Terman, G.L.; Cunningham, C.E.; Goven, M.G. and Struchtemeyer, R.A. (1952). Rate of planting and thiourea treatment for seed potatoes in Maine. Maine Agr. Expt. Sta. Bul. 505.

171. Thomas, J.E. and Riker, A.J. (1944). Loss incident to sprouting among stored potatoes reduced by hormone treatments. Phytopathol. 34: 1012 (Abstr.)

172. Thomas, W.L. and Eyre, P.W. (1951). Seed and its treatment. Early Potatoes. Faber and Faber Ltd. p. 52. (Data from J. Dept. Agric. Ire. (1918) 18 (2) p.163)

173. Thomson, B.F.(1945). Tissue responses to physiologically active substances. Bot. Rev. 11: 593-610.

174. Tinley, M.L. and Bryant, D.M. (1939). The relation between size of potato seed and planting distance. J. S.E. Agric. Coll. Wye, No. 44. 120-133.

175. Toosey, R.D. (1958). Effect of number of sprouts per set on yield and grading of main-crop potatoes. Nature. 182: 269-70.

176. ------------(1959). Control of sprout number in main-crop potatoes. Agriculture 66 (8) 346-50.

177. -------------(1960). Effect of number of sprouts per set on growth, yield and grading of maincrop potatoes.*

178. -------------(1962). Influence of presprouting on tuber number, size and yield of King Edward potatoes. Europ. Pot. J. 5(1), 23-27.

179. Vacha, G.A. and Harvey, R.B. (1927). The use of ethylene, propylene, and similar compounds breaking the rest period of tubers, bulbs, cuttings and seeds. Plants Physiol. 2: 187.

180. Vincent, C.L. (1930). Seed potato storage responses. Proc. Am. Soc. Hort. Sci. 27: 560-64.

---

* Paper read at First Triennial Conference of the European Association for Potato Research, Braunschweig - Voltunrode, September, 1960.

181. Vöchting, H. (1900). Zur physiologie der Knollengewächse. Jb., Wiss Bot. 34, 1.

182. Vries, H. DE. (1878). Die Beiträge zur speciellen Physiologie landwirtschaftlicher Kulturpflanzen. VI. Keimungsgeschichte der Kartoffelknollen Landw. Jb. 7, 217.

183.------------(1878). Die Beiträge zur speciellen Physiologie landwirtschaftlicher Kulturpflanzen. V. Wachstumgeschichte der Kartoffepflanzen. Landw. Jb. Wiss. Bot., 7, 591.

184. Wakankar, S.M. (1944). Influence of size of seed piece upon the yield of potatoes. J. Am. Soc. Agron. 36: 32-36.

185. Wallace, J.C. and Thompson, J.K. (1933). The optimum size of seed potatoes. Scot. J. Agric. 16: 241.

186. Wassink, E.C.; Krijthe, N. and Scheer, C. Van. Der. (1950) On the effect of light of various spectral regions on the sprouting of potato tubers. Proc. Acad. Sci. Amst. 53: 1228.

187.---------- and Scheer, C. Van Der (1950). On the study of the effects of light of various spectral regions on plant growth and development. Proc. Acad. Sci. Amst. 53: 1064.

188. Wellensiek, S.J. (1923). Ontigdige Knolvorming bij vroege aardappels. Medeel. Landbouwhoogesch., Wageningen, 27(3).

189. Werner, H.O. (1919). Potato Experiments. 1917 and 1918. N. Dakota. Agr. Expt. Sta. Bul. 129.

190.-------------(1949). Effect of position within a large storage bin upon mid-winter behaviour of Nebraska Triumph seed potatoes. Neb. Agr. Expt. Sta. Res. Bul. 158.

191. Westover, K.C.(1928). The effect on yield of sprout removal from potato seed tuber. Proc. Am. Soc. Hort. Sci. 25:91-96.

192.-------------(1937). The effect of the sun-greening of potato seed tubers on weight losses in storage and on subsequent field performance. Am. Pot. J. 14: 341-50.

193. Whitehead, T.; McIntosh, T.P. and Findlay, W.M. (1953). The potato in health and disease. Oliver and Boyd, Edinburgh. p. 744.

194. Wilson, A.R. and McKees, M.A. (1948). Prevention of excessive sprouting in late-stored ware potatoes. J. Min. Agr. 55, No. 7. 296-99.

195.------------ and Dawson, J.A. (1953). Residues of tetrachloronitrobenzene on ware potatoes. J. Sci. Food. Agr. 4: 305-310.

196. Wright, R.C. and Peacock, W.M. (1934). Influence of storage temperature on the rest period and dormancy of potatoes. U.S. Dept. Agr. Tech. Bul. No. 424.

197.-------------and Whiteman, T.M. (1949). The comparative length of dormant periods of thirty-five varieties of potatoes at different storage temperatures. Am. Pot. J. 26: 330.

APPENDICES

TABLE 93

Sub-Experiment 1, 1959-60

Average Number of Main-Stems per Hill

Treatment	Arran Pilot				Majestic			
	Samples Taken On			Av. Main-Stems per Hill	Samples Taken On			Av. Main-Stems per Hill
	June 8	June 23	July 8		June 8	June 23	July 8	
1	7.5	6.5	4.9	6.3	5.0	4.0	5.1	4.7
2	7.5	7.3	8.3	7.7	4.3	4.8	4.7	4.6
3	5.0	7.8	7.6	6.8	5.0	5.8	4.2	5.0
4	6.3	5.5	5.6	5.8	5.0	5.0	4.7	4.9
5	3.5	2.8	3.6	3.3	2.8	1.8	2.6	2.4
6	3.0	3.6	-	3.3	3.0	1.5	1.5	2.0
7	2.5	1.5	-	2.0	2.3	0.8	1.1	1.4
8	0.5	0.5	-	0.5	0.5	0.8	1.1	0.8
9	4.0	4.4	-	4.2	0.5	2.8	3.0	2.1
10	2.0	2.4	2.8	2.4	3.8	4.3	2.7	3.6
11	1.8	0.5	-	1.1	3.0	2.5	2.6	2.7
12	4.3	5.7	4.7	4.9	4.8	5.3	5.5	5.2
13	4.8	5.3	4.9	5.0	3.5	5.3	4.1	4.3
14	4.0	4.0	4.0	4.0	3.8	3.0	3.7	3.5

TABLE 94

Sub-Experiment 1, 1959-60

Average Number of Above-Ground Stems per Hill

Treat-ment	Arran Pilot: Samples Taken On						Arran Pilot	Majestic: Samples Taken On						Majestic
	June 8	June 23	July 8	July 23	Aug. 8	Aug. 23	Above-Ground Stems per Hill	June 8	June 23	July 8	July 23	Aug. 8	Aug. 23	Above-Ground Stems per Hill
1	7.8	7.2	9.7	9.5	12.0	12.0	9.7	5.0	4.6	5.8	6.4	4.2	4.0	5.0
2	10.3	8.4	8.5	7.8	11.0	11.0	9.5	4.3	4.7	5.3	6.0	7.0	6.3	5.6
3	6.6	11.5	7.3	8.5	9.5	8.8	8.7	6.7	5.8	4.3	6.5	5.0	6.5	5.8
4	9.3	7.3	10.4	10.0	10.5	8.3	9.3	5.0	6.0	4.8	6.8	6.3	5.3	5.7
5	4.0	3.5	-	6.1	-	2.0	3.9	4.8	5.0	5.0	5.5	5.5	6.0	5.3
6	4.9	7.3	-	-	4.0	7.0	5.8	5.0	4.8	-	4.7	2.5	3.0	4.0
7	3.0	2.7	-	4.5	-	4.2	3.7	4.3	4.2	-	5.0	5.0	3.5	4.4
8	1.8	4.0	-	3.6	3.0	-	3.1	3.3	4.8	2.9	-	3.0	4.0	3.6
9	5.1	5.0	5.8	5.0	3.0	5.5	4.9	2.3	3.0	2.5	3.2	5.0	2.0	3.0
10	2.4	2.3	3.5	5.0	6.3	1.5	3.5	3.8	5.8	2.8	4.5	3.7	4.0	4.1
11	1.8	0.5	3.0	-	1.0	1.7	1.6	3.5	2.5	2.0	-	4.0	3.0	3.0
12	5.6	5.7	8.0	8.0	6.0	5.7	6.5	4.8	5.5	4.8	5.9	6.0	4.8	5.3
13	7.8	7.3	6.7	7.5	7.8	5.5	7.1	4.0	5.3	4.8	3.8	4.2	4.3	4.1
14	5.5	10.3	7.0	6.3	8.0	6.7	7.3	5.5	5.3	4.3	4.3	7.0	6.0	5.4

TABLE 95

Sub-Experiment 1, 1959-60

Average Number of Tubers per Hill.

Treatment	Arran Pilot: Samples Taken On June 8	June 23	July 8	July 23	Aug. 8	Aug. 23	Arran Pilot: Av. Tubers per Hill (July 8-Aug.23)	Majestic: Samples Taken On June 8	June 23	July 8	July 23	Aug. 8	Aug. 23	Majestic: Av. Tubers per Hill (July8-Aug.23)
1	0.0	13.0	25.3	26.5	30.3	23.5	26.4	0.0	16.5	32.3	33.0	22.5	16.0	26.0
2	1.5	22.5	20.0	19.5	20.0	28.5	22.0	0.0	21.8	28.5	25.3	23.5	18.5	23.9
3	2.0	23.8	21.6	22.0	19.0	24.6	21.8	0.0	19.0	28.5	31.8	20.5	25.3	26.6
4	3.3	15.5	23.3	21.6	21.8	23.0	22.5	0.0	19.0	29.3	30.5	24.3	17.0	25.3
5	2.5	5.5	-	14.0	-	16.0	15.0	0.0	15.3	25.5	17.0	22.0	15.5	20.0
6	3.5	15.3	-	-	6.0	16.0	11.0	1.3	14.0	-	8.0	11.0	15.0	10.5
7	6.3	4.5	-	10.0	-	8.0	9.0	0.3	13.8	-	14.0	17.0	13.0	14.3
8	8.0	8.3	-	6.0	-	4.0	5.0	0.5	10.5	13.0	18.5	-	12.0	14.5
9	4.0	4.3	3.3	3.0	8.0	4.5	4.7	0.0	16.5	16.3	32.5	21.0	17.0	21.7
10	3.0	5.0	10.5	17.0	14.3	6.6	12.1	0.0	11.3	19.5	30.0	18.3	18.6	21.6
11	2.3	5.8	12.0	-	4.0	11.0	8.0	0.5	10.3	19.0	-	20.0	21.5	20.5
12	0.3	12.6	20.0	19.0	13.0	11.0	15.8	0.0	15.3	26.5	29.5	20.8	20.0	24.2
13	0.0	7.8	15.6	17.0	17.3	17.8	17.0	0.0	7.8	25.0	25.3	26.0	16.5	23.2
14	0.3	22.0	12.2	11.3	17.5	15.0	14.0	1.0	19.3	16.0	17.0	14.3	18.5	16.6

TABLE 96

Sub-Experiment 2, 1959-60

Average Number of Main-Stems per Hill.

Treatment	Arran Pilot				Majestic			
	Samples Taken On			Av. Main-Stems per Hill	Samples Taken On			Av. Main Stems per Hill
	June 14	June 30	July 14		June 14	July 30	July 14	
1	5.3	5.0	4.0	4.8	2.0	2.2	3.1	2.4
2	3.8	5.8	5.5	5.0	4.0	3.9	4.0	4.0
3	1.0	1.5	-	1.2	1.5	1.8	1.5	1.6
4	1.3	1.4	-	1.3	1.3	2.0	-	1.6
5	3.3	4.5	-	3.9	3.0	2.8	1.5	2.4
6	2.3	4.7	-	3.4	1.5	2.5	2.5	2.2
7	3.5	1.7	-	2.6	1.8	2.3	2.5	2.2
8	3.8	4.2	-	4.0	3.0	3.0	1.5	2.5

TABLE 97

Sub-Experiment 2, 1959-60

Average Number of Above-Ground Stems per Hill

Treat-ment	Arran Pilot							Majestic						
	Samples Taken On						Above-Ground Stems per Hill	Samples Taken On						Above-Ground Stems per Hill
	June 14	June 30	July 14	July 28	Aug. 11	Aug. 29		June 14	June 30	July 14	July 28	Aug. 11	Aug. 29	
1	7.0	9.3	6.0	6.0	4.8	5.3	6.4	3.8	3.3	3.4	3.5	4.0	3.0	3.5
2	5.5	7.3	5.8	8.0	5.3	7.7	6.6	6.0	5.0	4.5	3.8	6.0	3.5	4.8
3	2.5	2.0	-	-	-	4.8	3.1	5.3	4.5	5.7	6.0	4.3	6.0	5.3
4	2.0	2.5	2.0	2.5	-	3.0	2.4	4.5	5.8	-	-	4.0	3.7	4.5
5	6.5	5.5	4.0	7.5	9.0	-	6.5	6.3	6.5	5.8	3.6	5.0	4.0	5.2
6	6.0	8.0	5.8	4.7	6.5	5.0	6.0	3.5	4.8	3.7	4.8	5.3	4.3	4.4
7	6.5	5.0	5.5	-	9.0	7.5	6.7	3.0	2.8	3.6	2.3	2.8	3.5	3.0
8	6.3	4.7	7.7	4.5	7.0	7.0	6.2	5.0	3.0	4.4	3.7	4.5	4.0	4.1

TABLE 98

Sub-Experiment 2, 1959-60

Average Number of Tubers per Hill

Treatment	Arran Pilot: Samples Taken On June 14	June 30	July 14	July 28	Aug. 11	Aug. 29	Arran Pilot: Av. Tubers per Hill (July 14-Aug.29.)	Majestic: Samples Taken On June 14	June 30	July 14	July 28	Aug. 11	Aug. 29	Majestic: Av. Tubers per Hill (July 14-Aug.29)
1	0.8	14.8	13.5	10.9	13.8	11.8	12.5	0.3	14.5	21.8	12.3	13.0	13.8	15.2
2	0.5	9.3	13.3	17.5	15.3	13.6	15.0	0.5	19.5	26.3	18.0	22.8	13.5	20.1
3	3.5	3.3	-	-	-	13.3	13.0	1.0	14.0	19.0	18.5	12.0	14.5	16.0
4	5.0	7.0	7.0	6.0	-	14.0	8.3	0.3	15.8	-	-	10.0	6.0	8.0
5	7.8	10.0	10.0	12.4	13.0	-	11.8	3.0	20.5	17.0	15.0	16.0	12.8	15.2
6	2.5	8.3	14.0	8.7	20.5	8.0	12.8	5.8	19.0	17.5	20.3	17.8	15.2	17.7
7	3.8	10.5	13.0	-	11.0	20.4	14.8	0.3	16.3	18.7	14.3	13.3	16.5	15.7
8	1.8	13.5	16.3	9.1	16.0	9.0	12.6	1.8	19.0	23.3	20.3	18.8	15.6	19.5

TABLE 99

Experiment 1. 1959-60

Effect of Storage Treatments and Spacing on the Yield and Number of Different Grades of Tubers

Yield of Tubers (Tons per Acre)

Treatment	9"				18"			
	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total
1	14.2	9.0	0.3	23.5	17.8	6.4	0.3	24.5
2	14.1	8.7	0.5	23.3	15.1	5.1	0.2	20.4
3	16.4	9.1	0.3	25.8	15.7	5.6	0.2	21.5
4	15.9	8.2	0.2	24.3	15.2	5.6	0.2	21.0
12	16.4	4.9	0.1	21.4	19.7	4.1	0.1	23.9
13	18.4	7.1	0.2	25.7	19.3	4.7	0.2	24.2
S.E.	±1.0	±0.5	±0.08	±1.3	±1.0	±0.5	±0.08	±1.3

Number of Tubers (Thousands per acre)

1	72	121	23	216	75	92	16	183
2	72	112	26	210	65	65	12	142
3	78	114	21	213	65	75	15	155
4	74	81	20	175	61	76	17	154
12	71	65	12	148	72	53	8	133
13	78	91	15	184	75	60	14	149
S.E.	±4.7	±7.6	±2.2	±9.4	±4.7	±7.6	±2.2	±9.4

TABLE 100

Experiment 1, 1959-60

Effect of Storage Treatment, Variety and Spacing on the Yield and Number of Different Grades of Tubers

Yield of Tubers (Tons per Acre)

Treatment	Arran Pilot								Majestic							
	9"				18"				9"				18"			
	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total	Ware	Seed	Chats	Total
1	11.8	10.9	0.3	23.0	15.6	8.1	0.3	24.0	16.6	7.1	0.2	23.9	20.0	4.7	0.2	24.9
2	15.0	8.9	0.4	24.3	16.5	6.6	0.2	23.3	13.2	8.6	0.4	22.2	13.7	3.6	0.2	17.5
3	15.6	9.5	0.2	25.3	17.3	5.5	0.1	22.9	17.3	8.8	0.2	26.3	14.0	5.7	0.3	20.0
4	15.3	7.2	0.2	22.7	16.8	5.7	0.1	22.6	16.5	9.1	0.3	25.9	13.5	5.5	0.4	19.4
12	16.1	4.3	0.1	20.5	21.6	4.2	0.1	25.9	16.7	5.4	0.2	22.3	17.8	4.0	0.1	21.9
13	17.5	7.6	0.2	25.3	17.8	4.4	0.2	22.4	19.3	6.6	0.2	26.1	20.7	4.9	0.3	25.9
S.E.	±1.5	±0.8	±0.1	±1.9	±1.5	±0.8	±0.1	±1.9	±1.5	±0.8	±0.1	±1.9	±1.5	±0.8	±0.1	±1.9
	Number of Tubers (Thousands per Acre)															
1	61	151	25	237	64	122	20	206	84	92	19	195	85	62	12	159
2	73	110	22	205	68	83	9	160	71	114	30	215	61	48	15	124
3	70	126	15	211	64	73	10	147	85	106	23	214	65	76	22	163
4	66	84	16	166	62	74	10	146	81	77	26	184	60	77	24	161
12	67	56	7	130	74	52	4	130	76	73	17	166	69	54	12	135
13	73	99	13	185	65	53	9	127	83	84	16	183	84	67	21	172
S.E.	±6.7	±10.7	±3.1	±13.3	±6.7	±10.7	±3.1	±13.3	±6.7	±10.7	±3.1	±13.3	±6.7	±10.7	±3.1	±.3.3

ANALYSIS OF VARIANCE

List of Abbreviations

R	=	Replication
V	=	Variety
S	=	Spacing
T	=	Storage Treatments
Z	=	Seed Size
D	=	Dates of Chitting
L	=	Sprout Length Levels
S.S.	=	Sum of Squares
M.S.	=	Mean Sum of Squares
D.F.	=	Degrees of Freedom

TABLE 101

Experiment 1. 1959-60

Treatment Effect on the Emergence of Plants

Analysis of Variance

Due to	D.F.	S.S.	M.S.	F
R	1	77.22	77.22	1.64
V	1	1002.01	1002.01	21.32*
S	1	1643.22	1643.22	34.97**
VxS	1	110.01	110.01	2.34
Error 'a'	3	140.98	46.99	
T	13	2733.69	210.28	8.14**
T xV	13	2155.62	165.82	6.42**
T x S	13	613.40	47.18	1.83
T x V x S	13	381.62	29.35	1.14
Error 'b'	52	1343.29	25.83	
Total	111			

Effect of Low Temperature Storage, Heat Treatment and Chitting

Cold Storage vs Chitting in February (Tr.1,2,3) vs. (Tr.5,6,7)	1	247.52	247.52	9.58**
No Heat Treatment vs. Heat Treatment in November vs. Heat Treatment in January. (Tr. 1,5) vs. (2,6) vs. (3,7)	2	220.67	110.33	4.27*
Interaction	2	4555.29	2277.65	88.17**

TABLE 102

Experiment 2, 1959-60

Treatment Effect on the Emergence of Plants, 1960

Analysis of Variance

Due to	D.F.	S.S.	M.S.	
R	1	47.27	47.27	1.99
V	1	301.89	301.89	12.70*
S	1	1491.89	1491.89	62.78**
V x S	1	23.76	23.76	-
Error 'a'	3	96.79	32.26	-
T	7	312.36	44.62	2.32*
T x V	7	872.23	124.60	6.49**
T x S	7	52 .23	7.46	-
T x V x S	7	190.86	27.26	1.42
Error 'b'	28	537.44	19.19	
Total	63			

Components of Treatments (T)

TCNB vs No TCNB	1	1.27	1.27	-
Chitting at different dates	3	96.42	32.14	1.67
Interaction	3	214.67	71.56	3.73**
	7			

TABLE 103.

Experiment 1, 1959-60

Treatment Effects on the Final Yields of Potato Tubers

Analysis of Variance

Due to	D.F.	Gross		Ware		Seed		Chats	
		Total Yield M.S.	Total Number M.S.	Yield M.S.	Number M.S.	Yield M.S.	Number M.S.	Yield M.S.	Number M.S.
R	1	0.54	38.52	1.50	7.52	0.13	90.75	0.02	168.75
V	1	36.23	72.52	6.38	1788.52	81.38	4446.75	0.21	1083.00
S	1	288.61	42542.52**	218.88	892.69	958.55**	21336.33**	0.65	918.75
VS	1	296.51	136.69	177.13	379.69	10.55	5.33	0.06	30.08
Error 'a'	3	220.83	1123.19	138.41	279.91	26.67	441.36	0.13	193.69
T	5	118.95	7664.29**	247.47**	205.79	135.85**	5261.73**	0.33**	272.43**
TV	5	104.41	3169.62**	171.06*	407.42	64.65**	2882.10**	0.21**	182.90*
TS	5	171.87	2042.52	87.75	206.99	25.90	1231.68	0.09	107.45
TVS	5	75.66	1287.99	45.78	116.78	17.32	718.38	0.03	40.78
Error 'b'	20	83.30	848.02	53.28	216.46	13.88	562.66	0.04	47.85
	47								

Components of Treatment (T)

1. Cold Storage vs. Pit Storage.	1	72.80	19323.37 xx	1083.40 xx	372.09	539.13 xx	15504.17 xx	1.31 xx	1141.26 xx
2. Cold Storage and Heat Treatments.	3	91.56	4132.17 x	41.24	148.86	15.03	2682.75 x	0.14	5.95
3. Pit Storage (Despr. vs. undespr.)	1	247.28	6601.56 x	30.25	210.25	95.06 x	2756.25 x	0.20 x	203.06

Pertaining T x V

1. Cold Storage vs. Pit Storage x Var.	1	76.69	5280.66 x	1.62	1.76	48.88	4213.50 x		
2. Cold Storage and Heat Treatments x Var.	3	108.29	3521.46 x	221.52 x	564.37	88.95 xx	3318.92 xx	-	-
3. Pit Storage (Despr. vs. undespr.) x Var.	1	120.44	3.07	189.06	342.25	7.56	240.25		

TABLE 104

Sub-Experiment, 1960-61

Distribution of Sprouts[1] per Seed Tuber of Various Size (cm.) Group on 19.4.1961.

Arran Pilot

	Low Temperature Storage										TCNB									
	Large Seed					Small Seed					Large Seed					Small Seed				
	+	0-1	1-4	4-10	Tot	+	0-1	1-4	4-10	Tot.	+	0-1	1-4	4-10	Tot.	+	0-1	1-4	4-10	Tot.
November	1.6	8.1	2.8	1.1	13.6	1.1	4.7	2.1	1.1	9.0	0.8	6.7	1.6	1.6	10.7	0.6	6.4	1.9	0.9	9.8
December	0.4	10.0	1.0	2.7	14.1	1.2	9.1	0.3	1.9	12.5	0.8	9.2	0.6	2.4	13.0	1.3	6.0	0.3	1.7	9.3
January	1.1	13.2	1.0	2.1	17.4	0.6	8.0	0.2	2.2	11.0	-	9.1	1.0	1.9	12.0	0.9	7.5	0.8	2.0	11.2
February	0.9	14.1	3.0	0.4	18.4	0.1	8.6	2.5	0.3	11.5	0.1	15.0	2.2	1.2	18.5	-	8.5	1.9	0.5	10.9
No Chitting	3.9	9.8	-	-	13.7	0.8	8.9	0.3	-	10.0	-	Visible					Sprouts			

Majestic

	+	0-1	1-4	4-10	Tot	+	0-1	1-4	4-10	Tot.	+	0-1	1-4	4-10	Tot.	+	0-1	1-4	4-10	Tot.
November	0.6	3.0	1.0	-	4.6	1.5	1.3	1.2	-	4.0	1.0	2.6	1.1	-	4.7	0.7	2.7	1.1	-	4.5
December	1.8	4.7	1.0	-	7.5	1.4	2.7	1.1	-	5.2	1.1	3.0	1.7	-	5.8	0.7	2.3	1.2	-	4.2
January	2.8	7.9	1.3	-	12.0	1.2	6.7	1.2	-	9.1	1.9	8.1	2.0	-	12.0	1.7	6.0	1.7	-	9.4
February	0.9	10.1	2.4	-	13.4	1.2	10.1	1.5	-	12.8	1.1	12.4	2.5	-	16.0	0.9	9.4	2.0	-	12.3
No Chitting			Visible			Sprouts								Visible			Sprouts			

[1]Average of 10 Seed Tubers.

TABLE 105

Sub-Experiment, 1960-61

Loss of Fresh Weight (%) of Seed Tubers as Influenced by Methods of Storage, Seed Size and Dates of Chitting.

Dates of Chitting	Arran Pilot				Majestic			
	Low Temperature		TCNB		Low Temperature		TCNB	
	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed	Large Seed	Small Seed
November	11.5	10.4	11.0	11.0	11.3	12.5	12.3	10.2
December	11.3	11.1	11.1	11.2	7.9	10.3	8.4	7.4
January	10.0	10.6	10.5	10.8	8.1	7.2	6.5	6.0
February	7.8	7.9	7.9	8.5	9.2	9.5	7.4	6.5
No Chitting	9.2	4.7	4.8	5.1	4.3	5.9	4.9	5.3

TABLE 106.

Sub-Experiment, 1960-61

Loss of Fresh Weight (%) of Seed Tubers

as Influenced by Methods of Storage

Methods of Storage	Arran Pilot	Majestic
Low Temperature	8.9	8.6
TCNB	9.2	7.5

TABLE 107

Sub-Experiment, 1960-61

Loss of Fresh Weight (%) of Seed Tubers

as Influenced by Seed-Size

Seed-Size	Arran Pilot	Majestic
Large Seed	9.0	8.0
Small Seed	9.1	8.1

TABLE 108

Sub-Experiment, 1960-61

Dry Matter (%) in Potato Seed Tubers as Influenced by Methods of Storage, Seed-Size and Dates of Chitting

Dates of Chitting	Arran Pilot								Majestic							
	Low Temperature Storage				TCNB				Low Temperature Storage				TCNB			
	Large Seed		Small Seed		Large Seed		Small Seed		Large Seed		Small Seed		Large Seed		Small Seed	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
November	15.7	18.7	16.6	16.8	16.2	18.2	15.8	18.0	16.7	18.3	16.0	18.9	16.2	17.8	15.8	18.3
December	16.3	18.7	16.9	19.3	16.4	18.7	16.1	17.1	15.7	19.7	16.9	18.0	16.7	18.0	16.2	16.8
January	17.2	19.5	16.2	18.3	16.8	16.3	17.9	17.4	18.4	19.1	16.0	19.7	16.2	17.4	17.4	17.9
February	17.0	17.3	16.8	18.2	16.1	17.9	17.1	17.2	17.8	18.6	16.8	19.6	17.2	17.5	18.1	17.5
No Chitting	17.6	17.6	17.2	17.2	16.5	16.5	17.1	17.1	16.7	16.7	17.2	17.2	17.5	17.5	18.1	18.1

TABLE 109

Sub-Experiment, 1960-61

Dry Matter (%) in Seed Tubers as Influenced by Methods of Storage

Methods of Storage	Arran Pilot	Majestic
Low Temperature	17.4	17.6
TCNB	17.0	17.3

TABLE 110

Sub-Experiment, 1960-61

Dry Matter (%) in Seed Tubers as Influenced by Seed-Size

Seed-Size	Arran Pilot	Majestic
Large Seed	17.3	17.4
Small Seed	17.2	17.5

TABLE 111

Sub-Experiment, 1960-61

Dry Matter (g.) Changes of Foliage and Tubers at Different Stages of Plant-growth

Weight of Foliage (g.) per Hill

Arran Pilot

Dates of Chitting	Low Temperature Storage								TCNB Application							
	Large Seed				Small Seed				Large Seed				Small Seed			
	June 26	July 17	Aug. 7	Aug. 28	June 26	July 17	Aug. 7	Aug. 28	June 26	July 17	Aug. 7	Aug. 28	June 26	July 17	Aug. 7	Aug 28
November	21	43	59	25	19	32	38	11	26	71	55	18	18	39	51	21
December	30	42	45	6	16	35	41	9	24	35	61	12	19	36	62	33
January	26	35	37	12	15	28	46	19	22	67	62	8	17	33	41	13
February	27	39	46	7	13	40	63	13	29	43	43	4	14	26	41	12
No Chitting	33	38	56	24	12	33	54	25	14	34	53	38	7	30	34	13

Majestic

Dates of Chitting	June 26	July 17	Aug. 7	Aug. 28	June 26	July 17	Aug. 7	Aug. 28	June 26	July 17	Aug. 7	Aug. 28	June 26	July 17	Aug. 7	Aug 28
November	20	64	89	66	15	57	84	85	22	76	117	67	14	50	95	67
December	30	81	93	55	18	50	98	68	14	64	74	80	12	55	80	66
January*	28	84	101	72	9	71	75	77	22	63	95	83	-	-	-	-
February	20	65	96	75	15	43	64	78	22	70	84	59	17	57	71	53
No Chitting	14	41	101	69	9	47	79	54	8	37	98	76	5	42	79	66

* A shortage of small seed tubers of Majestic treated with TCNB.

Weight of Tubers (g.) per Hill

Arran Pilot

November	6	105	191	256	3	77	157	179	9	92	212	232	8	78	159	230
December	17	100	188	215	3	58	169	154	10	61	173	215	8	81	159	236
January	22	72	116	206	7	52	133	220	15	98	175	200	7	70	165	183
February	16	97	164	157	6	64	138	221	15	112	153	193	7	60	164	172
No Chitting	2	67	172	248	2	62	130	201	2	55	128	250	2	46	100	163

Majestic

November	4	67	200	277	3	56	200	315	5	76	231	294	2	60	192	223
December	8	95	193	297	3	53	155	310	3	71	165	320	2	62	173	302
January	13*	113	211	306	3	66	194	309	1	61	178	306	-	-	-	-
February	7	67	166	304	3	48	134	309	7	79	172	275	3	61	133	183
No Chitting	0.7	33	198	253	0.5	45	128	217	0.7	35	126	265	0.7	43	147	232

* A shortage of small seed tubers of Majestic treated with TCNB.

TABLE 112

Sub-Experiment, 1960-61

Number of Main-stems per Hill as Averaged from the Mean of Four Dates of Sampling

Arran Pilot

Dates of Chitting	Low Temperature Storage									
	Large Seed					Small Seed				
	June 26	July 17	Aug. 7	Aug. 28	Av.	June 26	July 17	Aug. 7	Aug. 28	Av.
November	4.8	4.7	4.0	3.3	4.2	1.7	2.7	1.7	2.7	2.2
December	3.7	3.0	3.3	2.3	3.1	3.7	3.0	2.7	3.0	3.1
January	3.3	3.0	3.0	2.3	2.9	2.7	2.7	5.3	3.0	3.4
February	3.0	3.7	3.0	2.7	3.1	2.3	3.3	2.7	3.0	2.8
No Chitting	8.3	9.0	11.3	7.0	8.9	6.0	11.3	7.3	5.3	7.5
Mean					4.4					3.8

Majestic

Dates of Chitting	June 26	July 17	Aug. 7	Aug. 28	Av.	June 26	July 17	Aug. 7	Aug. 28	Av.
November	1.0	1.0	1.7	2.0	1.4	1.0	1.3	1.7	1.7	1.4
December	1.3	2.0	1.7	1.7	1.7	1.0	1.0	1.0	1.7	1.2
January	1.7	1.7	1.3	2.3	1.8	1.7	1.3	2.3	1.0	1.6
February	1.7	2.3	2.3	1.3	1.9	2.0	2.0	1.3	2.0	1.8
No Chitting	5.3	5.7	6.0	5.0	5.5	3.3	3.7	4.0	3.7	3.7
Mean					2.5					1.9

Arran Pilot

Dates of Chitting	TCNB Application										Mean of Four dates of Lifting
	Large Seed					Small Seed					
	June 26	July 17	Aug. 7	Aug. 28	Av.	June 26	July 17	Aug. 7	Aug. 28	Av.	
November	3.0	3.7	2.0	2.3	2.8	3.3	2.0	2.3	5.3	3.2	3.1
December	3.0	2.7	3.3	3.0	3.0	2.3	2.3	2.7	2.3	2.4	2.9
January	2.7	2.7	2.7	2.7	2.7	2.3	2.3	2.3	2.3	2.3	2.8
February	3.0	3.0	2.7	2.7	2.9	2.7	2.7	2.7	2.0	2.5	2.8
No Chitting	5.3	4.7	7.7	9.7	6.9	4.7	7.3	5.0	5.7	5.7	7.2
Mean					3.7					3.2	

Majestic

November	1.3	1.7	1.3	2.3	1.6	1.0	2.0	1.0	1.3	1.3	1.4
December	1.7	2.0	1.3	1.7	1.7	1.3	1.0	1.7	1.0	1.3	1.5
January	1.3	1.7	2.3	1.7	1.8	-	-	-	-	-	1.7
February	3.3	2.3	2.3	2.3	2.6	1.7	2.0	1.3	1.7	1.7	2.0
No Chitting	6.3	5.0	3.7	4.7	4.9	3.0	2:3	3.7	3.0	3.1	4.3
Mean					2.5					1.8	

TABLE 113

Sub-Experiment, 1960-61

Number of above-ground Stems per Hill as Averaged from the Means of Four Dates of Sampling

Arran Pilot

Dates of Chitting	Low Temperature Storage									
	Large Seed					Small Seed				
	June 26	July 17	Aug. 7	Aug. 28	Av.	June 26	July 17	Aug. 7	Aug. 28	Av.
November	18.0	18.0	17.3	15.7	17.3	14.7	12.3	10.0	11.7	12.2
December	19.0	15.3	13.3	10.0	14.4	11.3	11.3	8.7	8.3	9.9
January	14.3	11.3	12.0	11.7	12.3	11.3	13.3	10.7	8.7	11.0
February	15.3	12.3	13.0	11.7	13.1	8.7	15.3	10.3	10.0	11.1
No Chitting	15.7	11.3	13.7	11.3	13.0	9.3	11.3	7.3	9.0	9.2
Mean					14.0					10.7

Majestic

November	4.7	2.7	5.3	5.0	4.4	3.0	4.0	5.0	6.0	4.5
December	6.0	5.3	3.3	3.7	4.6	5.7	5.0	3.7	3.0	4.4
January	4.7	6.3	4.7	6.0	5.4	4.0	3.7	5.3	4.7	4.4
February	5.7	6.3	7.0	6.3	6.3	6.3	5.0	6.0	4.0	5.3
No Chitting	5.3	6.7	6.3	5.0	5.8	4.0	4.0	4.0	4.0	4.0
Mean					5.3					4.5

Arran Pilot

	TCNB Application										
	Large Seed					Small Seed					
	June 26	July 17	Aug. 7	Aug. 28	Av.	June 26	July 17	Aug. 7	Aug. 28	Av.	Mean of Four dates of Lifting
November	21.9	13.7	14.7	11.7	15.5	16.0	14.7	11.0	8.3	12.5	14.4
December	20.7	12.7	16.7	12.0	15.5	13.7	20.7	10.0	8.7	13.3	13.3
January	8.7	18.0	13.3	11.3	12.8	12.0	11.3	10.3	10.7	11.1	11.9
February	17.4	16.3	10.3	9.7	13.4	11.3	9.3	9.7	9.3	9.9	11.9
No Chitting	13.7	10.0	10.0	11.7	11.4	9.0	9.7	7.7	8.0	8.6	10.6
Mean					13.7					11.1	

Majestic

	June 26	July 17	Aug. 7	Aug. 28	Av.	June 26	July 17	Aug. 7	Aug. 28	Av.	Mean of Four dates of Lifting
November	4.0	3.3	6.7	6.7	5.2	5.0	4.3	4.7	2.7	4.2	4.6
December	5.0	6.7	5.0	4.7	5.4	3.3	4.7	3.7	4.7	4.1	4.7
January	4.0	6.3	4.7	5.3	5.1	-	-	-	-	-	4.9
February	9.3	4.0	4.7	5.0	5.8	8.0	7.0	5.7	4.0	6.2	6.0
No Chitting	6.3	5.0	3.7	5.7	5.2	3.0	6.3	3.7	2.7	3.9	4.8
Mean					5.3					4.6	

TABLE 114

Sub-Experiment, 1960-61

Number of Tubers per Hill as Averaged from the Means of Last Sampling i.e. August 28.

Arran Pilot

Dates of Chitting	Low Temperature Storage									
	Large Seed					Small Seed				
	June 26	July 17	Aug. 7	Aug. 28	Av.	June 26	July 17	Aug. 7	Aug. 28	Av.
November	53.7	29.0	22.0	23.3	32.0	32.3	19.3	25.7	19.7	24.3
December	32.0	24.0	19.7	15.7	22.9	19.7	15.0	15.3	15.0	16.3
January	16.7	15.7	18.0	14.3	16.2	15.3	22.3	14.3	11.7	15.9
February	24.3	20.0	13.0	20.0	19.3	15.0	18.0	13.7	21.3	17.0
No Chitting	29.7	27.7	20.3	23.3	25.3	23.7	22.0	13.0	16.7	18.9
Mean				19.3					16.9	

Majestic

November	15.7	14.3	12.3	14.3	14.2	14.3	14.3	16.0	13.0	14.4
December	24.7	20.0	16.0	12.3	18.3	17.0	10.7	11.3	14.0	13.3
January	22.0	21.3	14.3	15.3	18.2	16.7	15.3	15.0	14.3	15.3
February	21.7	21.0	16.7	14.3	18.4	16.7	11.7	12.3	10.3	12.8
No Chitting	12.7	20.3	28.0	17.3	21.9	10.3	24.0	18.3	16.7	19.7
Mean				14.7					13.7	

Arran Pilot

	TCNB Application										
	Large Seed					Small Seed					
	June 26	July 17	Aug. 7	Aug. 28	Av.	June 26	July 17	Aug. 7	Aug. 28	Av.	Mean Aug.28
November	28.0	22.7	19.7	18.7	22.3	21.7	16.3	18.3	18.7	25.0	20.1
December	29.3	13.0	18.0	23.7	21.0	21.0	25.3	17.3	15.3	19.7	17.4
January	25.3	20.3	18.3	18.0	20.5	28.0	16.3	18.0	18.3	20.2	15.6
February	31.7	27.3	15.7	15.3	22.5	18.7	12.0	18.3	17.0	16.5	18.6
No Chitting	24.3	24.3	21.3	19.7	22.4	16.3	16.0	14.7	19.3	16.6	19.8
Mean				19.1					17.7		

Majestic

November	26.7	16.7	15.0	14.3	18.2	13.7	18.7	13.3	10.3	14.0	13.0
December	15.3	19.0	12.3	10.3	14.2	12.3	17.0	15.0	13.7	14.5	12.6
January	15.3	20.7	14.3	12.3	15.7	-	-	-	-	-	14.0
February	28.7	29.0	15.7	14.3	21.9	21.3	15.0	12.7	9.3	14.6	12.0
No Chitting	10.7	24.3	17.0	19.0	20.1	7.3	22.0	16.7	17.0	18.7	17.5
Mean				14.0					12.6		

TABLE 115

Experiment 1, 1960-61

Number of Above-ground Stems per Plot (9' x 4.5') in Thousands per Acre

Dates of Chitting	Replication	Arran Pilot								Majestic							
		9"				18"				9"				18"			
		Large Seed		Small Seed		Large Seed		Small Seed		Large Seed		Small Seed		Large Seed		Small Seed	
		Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB
November	I	429	368	334	396	245	188	210	196	101	147	90	117	68	57	46	60
	II	380	437	360	371	229	227	186	188	86	105	84	89	50	78	52	57
December	I	346	409	374	254	255	177	191	209	131	114	121	103	76	64	62	53
	II	422	299	386	354	182	230	155	182	103	107	86	96	53	59	50	50
January	I	386	502	366	302	178	163	191	153	120	138	123	127	90	53	68	75
	II	344	343	329	273	192	211	152	109	114	124	98	107	67	74	56	50
February	I	296	439	355	342	181	213	171	139	155	158	104	174	73	76	64	67
	II	372	366	430	303	217	169	145	141	135	153	98	127	74	85	58	64
No Chitting.	I	317	263	355	200	160	109	152	121	148	120	134	113	82	70	66	49
	II	374	247	239	241	188	169	130	84	149	130	116	114	96	76	81	56

TABLE 116

Experiment 2, 1960-61

The Influence of Chitting, Sprout-length Level and Variety on the Number of Above-ground Stems.

(Thousands/Acre)

Dates of Chitting	Arran Pilot			Majestic		
	L_1	L_2	L_3	L_1	L_2	L_3
November	209	182	171	54	48	52
December	155	186	154	64	66	56
January	194	147	155	74	60	72
February	164	190	138	54	66	68
No Chitting	143	127	154	58	73	63
S.E.	± 13.3	± 13.3	± 13.3	± 13.3	± 13.3	± 13.3

TABLE 117

Experiment 1, 1960-61

Total Yield of Potato Tubers per Plot (9' x 4.5') in Tons per Acre

Dates of Chitting	Replication	Arran Pilot								Majestic							
		9"				18"				9"				18"			
		Large Seed		Small Seed		Large Seed		Small Seed		Large Seed		Small Seed		Large Seed		Small Seed	
		Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB
November	I	16.1	17.5	18.7	16.0	17.1	17.3	15.4	13.5	24.2	25.9	21.9	21.8	24.7	21.5	22.4	21.2
	II	15.1	14.1	16.4	13.4	17.3	15.3	14.6	18.7	24.9	21.9	22.0	26.3	19.3	19.8	20.2	22.3
December	I	16.7	16.3	15.6	17.4	15.2	13.5	14.9	13.2	22.6	23.1	23.7	22.0	24.4	21.6	19.6	18.4
	II	13.3	14.0	14.4	16.5	14.9	15.5	16.3	14.8	24.5	22.6	25.2	22.8	21.8	22.2	18.5	22.0
January	I	15.1	16.8	16.4	16.1	14.9	16.8	15.4	17.5	23.4	22.9	21.9	26.4	21.4	19.4	21.2	24.0
	II	16.7	14.4	16.6	14.1	14.9	15.6	12.8	15.9	26.1	25.3	22.7	22.7	18.8	18.1	19.8	19.7
February	I	15.3	15.7	14.0	16.6	12.9	16.6	12.4	14.6	23.3	21.5	21.5	19.3	20.8	23.9	21.0	19.6
	II	15.9	17.2	15.3	14.3	12.1	13.6	15.0	17.5	23.7	24.6	22.1	25.8	22.6	19.1	21.5	19.4
No Chitt-	I	19.1	16.5	17.9	16.1	16.0	13.0	14.8	13.9	23.5	23.5	21.8	24.9	20.9	20.4	18.3	20.2
ing.	II	16.4	16.0	16.1	17.3	15.6	15.4	15.4	14.4	21.1	21.6	21.8	20.2	24.2	20.3	17.1	17.8

TABLE 118

Experiment 1, 1960-61

Yield of Ware Tubers per Plot (9' x 4.5') in Tons per Acre

Dates of Chitting	Replication	Arran Pilot								Majestic							
		9"				18"				9"				18"			
		Large Seed		Small Seed		Large Seed		Small Seed		Large Seed		Small Seed		Large Seed		Small Seed	
		Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB
November	I	0.9	1.1	1.5	2.2	5.6	7.4	3.7	2.5	7.2	6.6	6.0	8.4	15.8	12.6	14.7	11.5
	II	1.3	0.6	1.5	1.3	3.4	3.8	3.4	7.5	10.8	6.1	5.3	15.0	12.1	10.8	13.2	12.8
December	I	1.7	1.3	0.8	3.9	2.3	3.1	5.0	2.2	3.9	8.2	9.6	8.6	12.7	9.1	11.4	11.5
	II	0.9	0.9	2.5	2.4	4.6	3.8	9.1	2.9	10.2	10.1	9.9	7.8	14.5	12.9	11.3	13.8
January	I	1.2	1.4	3.7	1.2	4.8	5.8	5.3	6.1	5.8	4.6	4.6	11.3	7.5	10.6	11.1	15.1
	II	2.7	1.9	4.8	1.8	3.6	4.6	2.7	8.6	10.6	8.6	6.5	8.0	9.2	7.7	11.1	13.9
February	I	0.9	1.2	0.5	2.5	2.6	4.9	3.8	5.8	5.3	3.6	6.9	4.6	8.2	15.0	14.0	9.4
	II	1.7	1.3	1.7	2.6	3.4	7.0	4.3	8.2	7.5	5.1	7.4	9.7	13.4	8.6	14.5	11.3
No Chitt-	I	2.5	1.4	0.9	1.3	5.0	2.2	2.5	3.6	5.8	3.8	5.3	8.0	4.8	2.0	5.8	7.4
ing.	II	0.1	1.5	0.7	0.9	4.3	2.4	3.7	4.4	1.9	2.2	4.4	4.3	10.8	4.4	6.9	6.5

TABLE 119

Experiment 1, 1960-61

Yield of Seed Tubers per Plot (9' x 4.5') in Tons per Acre

Dates of Chitting	Replication	Arran Pilot								Majestic							
		9"				18"				9"				18"			
		Large Seed		Small Seed		Large Seed		Small Seed		Large Seed		Small Seed		Large Seed		Small Seed	
		Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB
November	I	13.8	14.7	15.7	12.3	10.4	8.9	10.3	10.1	16.1	18.6	15.4	13.0	8.5	8.5	7.5	9.1
	II	13.0	11.4	13.0	10.4	12.9	11.0	10.4	10.6	13.4	14.5	16.1	10.9	7.0	8.4	6.7	8.9
December	I	13.2	13.0	11.8	11.8	11.6	9.6	9.2	10.2	17.8	14.2	13.5	12.8	11.3	11.8	7.8	6.6
	II	10.6	11.4	10.6	12.5	9.8	10.6	6.7	10.6	13.7	12.1	14.9	14.4	7.0	8.9	6.7	7.9
January	I	12.1	13.3	11.5	13.3	9.6	10.4	9.6	11.0	16.9	17.4	16.1	14.2	13.4	8.5	9.2	8.4
	II	12.6	11.1	10.3	10.9	10.3	10.4	9.4	6.7	14.7	15.8	15.6	14.4	9.2	10.1	8.2	5.5
February	I	12.8	12.8	12.0	13.0	9.8	10.8	8.0	8.5	17.0	17.0	14.0	14.2	12.3	8.5	6.6	9.7
	II	12.7	14.4	12.5	10.4	7.8	9.8	10.2	8.7	15.4	18.5	14.2	15.6	8.5	10.1	6.8	7.5
No Chitting.	I	15.4	14.0	15.4	13.8	10.1	9.6	11.6	9.6	17.0	18.7	15.6	16.1	15.4	17.1	11.8	12.6
	II	14.0	12.8	14.0	14.4	10.6	12.3	10.9	9.1	18.2	18.2	16.6	15.4	13.0	15.2	9.6	11.0

TABLE 120

Experiment 1, 1960-61

Total Number of Potato Tubers per Plot (9' x 4.5') in Thousands per Acre

Dates of Chitting	Replication	Arran Pilot								Majestic							
		9"				18"				9"				18"			
		Large Seed		Small Seed		Large Seed		Small Seed		Large Seed		Small Seed		Large Seed		Small Seed	
		Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB
November	I	356	245	294	269	228	193	230	193	259	278	221	181	171	163	133	173
	II	280	297	303	299	231	188	193	201	237	251	235	202	126	163	121	160
December	I	252	292	316	253	251	216	186	191	276	232	219	237	183	185	146	130
	II	273	226	252	285	180	213	153	231	230	211	205	217	139	148	144	144
January	I	283	325	251	278	158	178	163	130	274	241	262	258	196	152	190	162
	II	255	239	264	242	226	182	178	152	243	263	242	212	154	141	160	118
February	I	284	317	267	241	169	184	145	147	269	269	206	226	176	183	156	168
	II	273	296	244	252	167	204	183	174	244	283	189	232	167	158	134	141
No Chitting.	I	302	270	316	249	201	211	185	190	271	278	249	259	232	266	190	189
	II	357	268	264	332	196	187	216	182	291	300	254	172	197	218	164	145

TABLE 121

Experiment 1, 1960-61

Number of Ware Tubers per Plot (9' x 4.5') in Thousands per Acre

Dates of Chitting	Replication	Arran Pilot								Majestic							
		9"				18"				9"				18"			
		Large Seed		Small Seed		Large Seed		Small Seed		Large Seed		Small Seed		Large Seed		Small Seed	
		Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB
November	I	4	3	9	11	26	31	17	13	35	31	25	32	61	53	54	48
	II	6	3	7	5	17	17	17	28	47	27	26	64	46	42	43	43
December	I	9	7	3	15	12	13	22	12	16	38	41	34	50	36	44	41
	II	5	5	14	12	20	17	32	13	44	44	39	34	49	47	45	52
January	I	6	7	12	7	21	27	24	24	26	22	21	52	33	38	41	53
	II	12	9	19	11	16	21	13	34	45	41	34	36	38	28	42	50
February	I	5	6	3	12	13	20	20	25	22	17	25	21	38	58	55	32
	II	6	6	7	12	13	39	20	40	34	25	34	43	56	36	52	47
No Chitting.	I	6	7	5	6	22	12	14	17	28	18	26	16	25	10	27	35
	II	1	9	3	5	30	11	15	20	10	12	22	21	46	20	33	30

TABLE 122

Experiment 1, 1960-61

Number of Seed Tubers per Plot (9' x 4.5') in Thousands per Acre

Dates of Chitting	Replication	Arran Pilot								Majestic							
		9"				18"				9"				18"			
		Large Seed		Small Seed		Large Seed		Small Seed		Large Seed		Small Seed		Large Seed		Small Seed	
		Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB	Low Temp.	TCNB
November	I	241	144	212	180	136	109	141	129	174	200	164	119	92	83	70	93
	II	166	175	182	175	155	143	125	140	143	171	171	111	69	87	64	88
December	I	135	180	136	159	166	142	124	136	205	148	146	144	109	111	78	73
	II	156	129	162	171	124	140	95	146	143	134	139	143	75	85	71	74
January	I	182	206	155	185	107	119	112	88	201	164	186	157	134	92	106	81
	II	170	153	159	156	162	123	123	79	156	168	166	147	89	96	90	54
February	I	195	221	175	178	131	124	100	101	186	200	144	160	123	93	74	105
	II	170	210	167	154	102	129	128	110	159	199	130	161	84	99	68	63
No Chitting.	I	224	204	218	187	128	132	145	131	197	210	174	191	163	185	125	129
	II	221	189	185	219	135	132	146	116	228	223	181	119	128	160	100	103

TABLE 123

Experiment 1. 1960-61
Germination Rate Index

Analysis of Variance

Due to	D.F.	S.S.	M.S.	F
R	1	0.036	0.036	12.00
V	1	0.553	0.553	184.33**
Error 'a'	1	0.003	0.003	-
S	1	0.010	0.010	1.67
Z	1	0.129	0.129	21.50**
S x Z	1	0.000	0.000	-
S x V	1	0.000	0.000	-
Z x V	1	0.003	0.003	-
S x Z x V	1	0.006	0.006	1.00
Error 'b'	6	0.037	0.006	-
T	9	3.192	0.354	177.00**
T x V	9	0.136	0.015	7.50**
T x S	9	0.009	0.001	-
T x Z	9	0.063	0.007	3.50**
T x V x S	9	0.015	0.001	-
T x V x Z	9	0.031	0.003	1.50
T x S x Z	9	0.028	0.003	1.50
T x V x S x Z	9	0.036	0.004	2.00
Error 'c'	72	0.181	0.002	-
Total	159			
		Components of Treatments (T)		
1. Low Temp. vs. TCNB	1	0.000	0.000	-
2. Chitting vs. No Chitting	1	3.071	3.071	1535.50**
3. Chitting at Different Dates.	3	0.082	0.027	13.50**
4. Chitting x Method.	4	0.039	0.009	4.50**
		Pertaining (T x V)		
1. Low Temp. vs. TCNB x Variety.	1	0.006	0.006	3.00
2. Chitting vs. No Chitting x Variety.	1	0.004	0.004	2.00
3. Chitting at Different Dates x Variety.	3	0.082	0.027	13.50
4. Chitting x Method x Variety.	4	0.044	0.011	5.50**

TABLE 124.

Experiment 1, 1960-61

Number of Above-ground Stems

Analysis of Variance

Due to	D.F.	S.S.	M.S.	F
R	1	2153.55	2153.55	81.54
V	1	1002197.30	1002197.30	37947.64^{xx}
Error 'a'	1	26.41	26.41	-
S	1	434826.75	434826.75	492.73^{xx}
Z	1	21832.25	21832.25	24.74^{xx}
S x Z	1	166.06	166.06	-
S x V	1	117343.06	117343.06	132.96^{xx}
Z x V	1	4378.56	4378.56	4.96
S x Z x V	1	0.76	0.76	-
Error 'b'	6	5294.89	882.48	-
T	9	32558.53	3617.61	4.69^{xx}
T x V	9	49742.63	5526.96	7.16^{xx}
T x S	9	8903.18	989.24	1.28
T x Z	9	4948.68	538.74	-
T x V x S	9	5471.39	607.93	-
T x V x Z	9	8838.39	982.04	1.27
T x S x Z	9	3630.40	403.38	-
T x V x S x Z8	9	5471.39	607.93	-
Error 'c'	72	55542.91	771.43	
Total	159			

Components of Treatments (T)

Due to	D.F.	S.S.	M.S.	F
1. Low Temp. vs. TCNB.	1	2730.75	2730.75	3.54
2. Chitting vs. No Chitting.	1	17587.53	17587.53	22.79^{xx}
3. Chitting at Different Dates.	3	2176.22	725.41	-
4. Chitting x Method.	4	10064.03	2516.01	3.26^{x}

Pertaining (T x V)

Due to	D.F.	S.S.	M.S.	F
1. Low Temp. vs. TCNB x Variety.	1	4676.41	4676.41	6.06^{x}
2. Chitting vs. No Chitting x Variety.	1	32106.39	32106.39	41.62^{xx}
3. Chitting at Different Dates x Variety.	3	12034.46	4011.49	5.20^{x}
4. Chitting x Method x Variety.	4	925.37	231.34	-

TABLE 125

Experiment 2, 1960-61

Germination Rate Index

Analysis of Variance

Due to	D.F.	S.S.	M.S.	F
R	1	0.001	0.001	-
V	1	0.092	0.092	18.400
Error 'a'	1	0.005	0.005	-
D	4	0.942	0.235	117.500**
D x V	4	0.011	0.002	1.000
Error 'b'	8	0.017	0.002	-
L	2	0.005	0.002	-
L x V	2	0.043	0.021	5.250*
L x D	8	0.070	0.008	2.000
L x V x D	8	0.052	0.006	1.500
Error 'c'	20	0.092	0.004	
Total	59			

TABLE 126

Experiment 2, 1960-61

Number of Above-ground Stems

Analysis of Variance

Due to	D.F.	S.S.	M.S.	F
R	1	1152.82	1152.82	2811.75**
V	1	136994.82	136994.82	334133.70**
Error 'a'	1	0.41	0.41	-
D	4	1628.10	407.02	-
D x V	4	4777.77	1194.44	2.20
Error 'b'	8	4336.27	542.03	-
L	2	1235.54	617.77	2.02
L x V	2	1445.04	722.52	2.36
L x D	8	3331.80	416.47	1.36
L x V x D	8	2284.62	285.57	-
Error 'c'	20	6103.00	305.15	-
Total	59			

TABLE 127

Experiment 1, 1960-61

Effect of Treatments on the Final Yield and Number of Tubers

Analysis of Variance

Due to	D.F.	Gross Yield		Yield of Ware		Yield of Seed		Yield of Chats	
		Total Yield M.S.	Total No. Tubers M.S.	Yield M.S.	Number M.S.	Yield M.S.	Number M.S.	Yield M.S.	Number M.S.
R	1	19.88	3715.26	55.46	247.51	109.89	3950.16	0.63	170.15
V	1	7187.76**	33148.81	5837.01*	17201.76*	231.36	15780.76	55.70*	35491.80
Error 'a'	1	0.44	2504.31	11.24	43.06	9.31	1118.31	0.66	573.81
S	1	461.04**	240017.56**	1907.16**	4984.06**	3281.53**	131274.31**	52.21**	38968.80**
Z	1	34.78	15980.01**	138.38*	209.31	278.26**	10288.06**	2.60**	1619.25
SZ	1	3.54	131.41	0.11	9.51	8.46	7.66	0.26	120.70
SV	1	1113.57	1237.66	35.53	24.81	433.62**	2363.91*	12.77**	7742.31**
ZV	1	29.41	2023.51	17.56	11.56	75.34	2095.26*	0.09	3.31
SZV	1	0.55	841.80	0.02	2.75	1.09	174.30	0.34	223.32
Error 'b'	6	19.70	411.88	11.64	36.13	16.55	263.96	0.10	523.69
T	9	11.58	2003.33**	99.76**	250.87**	69.50**	2747.53**	0.33	238.78
TV	9	14.04	1541.58	66.24**	179.12**	30.04**	796.51**	0.55	618.29**
TS	9	5.48	617.92	27.89	70.75	10.71	698.83**	0.25	180.99

TZ	9	7.57	410.64	21.09	67.67	6.37	302.69	0.27	72.44
TVS	9	15.77	384.05	15.72	40.72	14.37	513.29	0.45	223.07
TVZ	9	7.30	785.78	15.28	44.14	7.28	505.09	0.39	117.79
TSZ	9	10.37	403.43	16.30	66.26	12.58*	327.27	0.27	141.94
TVSZ	9	14.57	404.86	26.13	52.78	7.25	285.61	0.23	123.29
Error 'c'	72	11.58	474.16	13.39	45.50	5.82	248.64	0.34	176.99
Total	159								
Components of Treatments (T)									
Cold Storage vs. TCNB Storage.	1	0.00	660.15	1.52	1.05	0.53	283.55	-	-
Chitting vs. No Chitting.	1	11.37	12188.82**	808.65**	1974.02**	568.55**	20325.82**	-	-
Chitting at Different Periods.	3	18.48	624.11	9.48	10.68	8.76	433.17	-	-
Chitting x Method	4	9.36	827.17	14.43	62.67	7.53	704.71*	-	-
Pertaining (T x V)									
Cold Storage vs. TCNB Storage x Variety.	1	1.81	339.30	11.34	66.30	1.30	24.80	-	-
Chitting vs. No Chitting x Variety.	1	61.82	2041.32**	357.60**	888.30**	112.00**	1994.62**		
Chitting at Different Periods x Variety.	3	3.18	2797.74**	43.09*	112.72	28.28**	993.47**		
Chitting x Method x Variety.	4	13.30	775.11	24.48	79.82	18.07	542.18	-	-

TABLE 128

Experiment 2, 1960-61

Effect of Treatments on the Final Yield of Potato Tubers

Analysis of Variance

Due to	D.F.	Gross Yield: Total Yield M.S.	Gross Yield: Total Number M.S.	Yield of Ware: Yield M.S.	Yield of Ware: Number M.S.	Yield of Seed: Yield M.S.	Yield of Seed: Number M.S.	Yield of Chats: Yield M.S.	Yield of Chats: Number M.S.
R	1	225.81	77.07	104.01	201.66	24.45	64.07	0.02	147.27
V	1	2366.30*	23128.07**	5464.51**	11760.00*	497.09	34081.67*	9.05*	5960.07
Error 'a'	1	11.98	1.00	1.18	48.60	22.20	101.39	0.04	-
D	4	8.68	9280.43*	126.73*	223.96*	64.49	1993.94*	0.48*	285.96
D x V	4	15.42	6347.43	41.32	56.62	45.97	939.29	0.34*	319.94*
Error 'b'	8	10.74	447.70	18.63	41.09	18.11	305.98	0.08	-
L	2	48.08**	5158.50**	4.25	1.75	51.51*	1250.52**	0.27	141.06
L x V	2	1.37	3532.17**	71.52	138.25	56.16**	1648.56**	0.19	133.90
L x D	8	8.84	4946.67*	22.23	86.12	24.06*	579.34**	0.25	125.88
L x V x D	8	10.20	1739.33	15.69	40.25	17.33	306.50	0.16	59.54
Error 'c'	20	7.89	191.31	22.30	55.25	9.09	145.28	0.16	
Total	59								